fronting the Title page

THE TERRESTRIAL GLOBE

THE

USE
OF THE
GLOBES:

OR,

The General Doctrine
OF THE
SPHERE:

Explaining and Demonstrating the most natural PROPOSITIONS relating to *Astronomy*, *Geography*, and *Dialing*.

To which is added,

A *SYNOPSIS* of the Doctrine
OF
ECLIPSES.

The whole illustrated with a great Number of *Copper-Plates*, explanatory of each PROPOSITION, in a Manner intirely new.

By *THOMAS WRIGHT*,
Of the City of DURHAM.

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G.R.III.
P.R.MUS.

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THE INTRODUCTION,

CONTAINING

A Brief ACCOUNT of the UNIVERSE and of the SOLAR SYSTEM.

BEFORE we proceed to ſhew the ſeveral Uſes of the Globes, (whereof the one repreſents the Starry Firmament, and is therefore called the *Celeſtial*; the other, the Diſpoſition of the Earth and Water of the Globe we inhabit, and is therefore called the *Terraqueous*, or *Terreſtrial*) it may be proper to premiſe ſomething of the *Univerſe* in general, and of the *So-*

lar Syſtem in particular, of which they are reſpectively ſuppoſed to repreſent a part.

Now by the *Univerſe* we are to underſtand the general Frame of Nature, even to the utmoſt Bounds and Extent of the Creation. The annexed Scheme (Pl. I. Fig. 1.) repreſents a partial View of it, being founded upon this Hypotheſis, That the Stars are ſo many Suns; that each of theſe Stars or Suns is attended, (as ours is,) by a proper number of Planets and Comets; and that each hath a gravitating Power independent of each other.

As, therefore, theſe ſeveral Syſtems cannot interfere with one another, the Univerſe or the whole Space that envelopes them all muſt be vaſtly immenſe, too boundleſs and extenſive for human Reaſon to comprehend. For if that ſmall Part of it, which we are acquainted with, takes up, (as is proved from the Motion of the

the Comet* of 1680,) the Space of at leaſt 22,400,000,000 Miles in Diameter, how immenſly great or infinite rather muſt be the whole?

This was long ago the Opinion of the famous Aſtronomer *Hipparchus*; who alſo thought it probable, that there were Stars, whoſe Light would be 100,000 Years in coming to the Earth.

But, to ſpeak of that Part of the Univerſe, which we may call the viſible World, or Solar Syſtem, made more intelligible and adequate to our Faculties, by Teleſcopic and other Obſervations: We ſhall take it for granted that the Sun is the Center of it; and that our *Earth*, together with *Saturn*, *Jupiter*, *Mars*, *Venus*, and *Mercury*, are the Pla-

* This Comet (whoſe Tail in its Aſcent from the Sun was 80,000,000 of Miles long; and which, near the Perihelion Point, moved with a Velocity almoſt equal to that of Light, much quicker than that of a Cannon-Ball when firſt diſcharged, moved in an Orb ſo vaſtly eccentrical, that when it came to its Aphelion, it was fourteen times farther diſtant from the *Sun* than *Saturn*, the higheſt Planet of our Syſtem, and whoſe Diſtance is about 777,000,000 Miles.

nets or wandring Stars which move round about it. Theſe, to us, appear like Stars of the firſt Magnitude; as the *Earth* or Planet, we live upon, muſt, in like manner, appear to them.

And then again, as theſe Planets, which we may call primary ones, perform their Revolutions round the Sun; ſo there are others, of a ſecondary Nature, that attend likewiſe ſome of Them. Thus the *Earth* has one ſecondary Planet or *Satellit*, viz. the *Moon*, performing its Revolution, in a ſtated Period, about it. *Saturn* has five, and *Jupiter* four, performing the like Offices.

Beſides the Planets, both primary and ſecondary, here mentioned, there are other Bodies likewiſe that make a part of this Syſtem. Such are the Comets; the Deſcription whereof being not neceſſarily required in this Syſtem, we muſt refer the Reader to Dr. *Halley*'s *Synopſis of Comets*,

Comets, inſerted at the end of Dr. *Gregory*'s *Aſtronomy*.

Firſt then, the *Sun*, the Center of this Syſtem, which diſpenſes Light and Heat to the whole, is obſerved to revolve about its Axis, from Weſt to Eaſt, in about 25 $\frac{1}{4}$ Days. Its Diameter is found to be 763,000 Miles.

Next to the *Sun* is *Mercury*, which is not yet known to move round its own Axis. It is 27 times leſs than the Earth; makes one Revolution round the Sun in 87 Days, 23 Hours, 15 Minutes and 54 Seconds; from which its mean Diſtance is 32,000,000 Miles.

Venus, the brighteſt of the primary Planets, is three times leſs than the *Earth*; moves round its own Axis in 23 Hours, being 59,000,000 Miles, at a mean Diſtance, from the Sun; about which it performs its Revolution in 224 Days, 16 Hours, 49 Minutes, and 27 Seconds.

Theſe two Planets are called *inferiour* Ones, inaſmuch as they are circumſcribed within the *Earth*'s Orbit; neither is the greateſt Elongation or Diſtance of the former from the Sun, ever found to be more than 28°, or, of the latter, more than 48°. This proves that each of them has a Motion round the Sun, and at the ſame time ſhews the Reaſon, why *Mercury* is ſo ſeldom viſible, and that *Venus* becomes our Morning and Evening Star, as her Aſpect is Eaſtward or Weſtward of the Sun.

The next Planet to *Venus* is the *Earth* we live upon, which is carried about the Sun in 365 Days, 5 Hours, and 48 Minutes. This Revolution is commonly called a Year, and by Aſtronomers a *Tropical* Year, to diſtinguiſh it from the *Sidereal*, which, depending on the Preceſſion of the Equinoxes, is ſomewhat longer. But of this we ſhall ſpeak hereafter.

Be-

Beſides the Annual, the *Earth* has alſo a diurnal Motion upon its own Axis, in the Space of about 23 Hours, 56 Minutes: and thereby affords us the Interchange of Day and Night. This Motion is from Weſt to Eaſt; by virtue of which, we, that are carried along the Surface, obſerve every Object placed above us, (ſuch as the Sun, Moon, and Stars,) to move the contrary way. Now that Space of Time which the Sun ſeems to take up in paſſing from any fixed Meridian to its Return to the ſame, is called a natural Day, conſiſting exactly of 24 Hours.

We are to obſerve farther of the *Earth*, that the Diameter of it is 7,969 Miles, the Circumference 250,358; whereby the Quantity of a Degree in the Arch of a great Circle will be about 70 Miles. The mean Diſtance of it from the Sun is 81,000,000 Miles; and the Bigneſs of it, with regard to the ſame

Luminary, is only one 200,000th Part. The higheſt Verge of the Atmoſphere or Region of Clouds and Vapours is about 48 Miles.

The *Earth* has a ſecondary Planet, or Satellit, moving round it, which is the *Moon*; being about one fiftieth Part as big as the *Earth*, and is at the Diſtance of about 240,000 Miles from it. This is the moſt irregular of the Planets, occaſioned firſt by her proper Motion, about the *Earth*, round her own Orb; and then ſecondly, as ſhe is carried, along with the *Earth*, round the Sun. However, ſhe is obſerved to go once round upon her Axis in 27 Days, 7 Hours, and 43 Minutes; and in the like Space, to perform one Revolution round the *Earth*; which is the Reaſon, that ſhe always preſents the ſame Side or Hemiſphere to us. She finiſheth her monthly Revolution in about 29½ Days, after having continually

tinually changed her Phaſes or Aſpects with regard to the Sun.

Mars, the next Planet in the Syſtem, is, with regard to the *Earth*, called a ſuperior Planet, becauſe the *Earth* is circumſcribed within its Orb. It is however about 15 times leſs than the *Earth*, though 42,000,000 Miles farther Diſtant from the Sun; round which it revolves in one Year, 321 Days, 23 Hours, and 27 Minutes. The Motion round its own Axis is performed in 24 Hours, and 40 Minutes.

Jupiter, the next Planet in order, makes one Revolution round the Sun in 11 Years, 317 Days, 12 Hours, 20 Minutes, and 24 Seconds; from which it is diſtant 424,000,000 Miles. It is 6054 times bigger than the *Earth*, and turns round upon its Axis once in 9 Hours and 57 Minutes.

Saturn, the remoteſt Planet in this Syſtem, is diſtant from the Sun 777,000,000

777,000,000 Miles, and performs its Period in 29 Years, 174 Days, 6 Hours, and 36 Minutes. It is 298 times bigger than the *Earth*, and revolves about its Axis once in 29 Days, 10 Hours and 1 Minute.

This Planet has a flat Ring, or Zone, that ſurrounds it, which, to the Eye, looks ſometimes like the Horizon, placed round an artificial Globe; though at other times it has an oval or different Aſpect. It is diſtant from *Saturn* near one third of *Saturn*'s Diameter; being likewiſe nearly of the ſame Brightneſs.

Both *Saturn* and *Jupiter* have their Satellites or ſecondary Planets; but as they are not viſible to the Eye, we ſhall take no farther Notice of them, than as they are placed in the annexed Schemes, to which we refer the Reader. Pl. II. and III.

The proportional Magnitudes of the foregoing Planets, are according to

to Mr. *Street*'s Tables. Mr. *Whiſton* lays down their reſpective Diameters in the following Manner, *viz.*

Saturn - - - -	61,000 Miles.
Jupiter - - - -	81,000
Mars - - - - - -	4,440
Earth - - - - -	7,970
Venus - - - - -	7,900
Mercury - - -	4,248
The *Moon* - - -	2,170

Now all theſe Planets, whether primary or ſecondary ones, borrow all their Light from the Sun; and do not therefore appear ſo bright and twinkling as the Stars, whether they are viewed with the naked Eye or by Teleſcopes. And there is likewiſe this further Difference betwixt Them and the Stars, that theſe are called *fixed*, (as never altering their Places in the Heavens,) whereas the other are called *erratick* or *wandring*; inaſmuch as they are continually ſhifting, (in the ſame manner the Sun is obſerved

ved to do,) from one ſide of the *Equator* to the other, according to the reſpective Periods of their Revolutions.

Theſe are the Phænomena we are to account for and ſolve by the *Celeſtial* Globe; as the *Terreſtrial* will ſhew us the Diſpoſition of Land and Sea; the Situation of Places, with regard to one another; the Inequality of the Seaſons, *&c.* and ſolve various Problems relating to Geography and Navigation.

So much we thought fit to premiſe by way of *Introduction.*

The USE of the GLOBES.

CHAP. I.

Of a GLOBE *in General*, &c.

BY a Globe is to be underſtood, a ſpherical or orbicular Body, *i. e.* either phyſically or mathematically round; which we may conceive to be form'd by the Revolution of a circular Plane, upon any two oppoſite Points, in the Perimeter.

Now all Parts of its Surface being ſuppoſed to be equally diſtant from the Point in the middle of it, that Point is called the *Center*; about which, if we conceive it to revolve,

revolve, there will be one right Line paſſing through the Center each way to the Circumference, which will be immovable. This Line is called the *Axis*.

A Globe therefore, in all manner of Directions, will be bounded by a Circle: to meaſure which, it is ſuppoſed to be divided into 360 Parts, called Degrees. Theſe again are each of them ſubdivided into 60 Parts, called Minutes; and, if requir'd, every Minute may be ſubdivided into the like number of Seconds.

To the Eye of an Obſerver, placed in any unbounded Space, all remote Objects, ſuch as the Stars, *&c.* will appear at equal Diſtances, and will continue to do ſo without any ſenſible Variation, altho' we change our Situation many thouſand Leagues. And in this manner "the Heavens will appear "to us like a vaſt concave Sphere, the Sur-. "face of which is ſtudded with an innu- "merable multitude of Stars, all appearing "at the ſame Diſtance; tho' ſome of them, "in all probability, are many Millions of "Miles nearer to us than others." A Globe conſequently formed in this manner, wherein the Eye is ſuppoſed to be the Center, may be a ſufficient Repreſentation of the Heavens, or of the Starry Firmament.

CHAP.

CHAP. II.

Of the Celeſtial GLOBE.

THE Celeſtial Globe therefore repreſents this Sphere, commonly called the Starry Firmament; on which are drawn divers Images and Figures, invented by the antient and continued by modern Aſtronomers, and called by them both, Aſteriſms, or Conſtellations. The Number of them, according to the Moderns, is 80; 12 of which, being of more particular Note, and lying in the Sun's Way over the Torrid Zone, are commonly called the Signs of the Zodiack, or of the Solar Orb.

The principal Parts of this GLOBE *are,* Plate IV.

I.

The Orb or Globe it ſelf.

II.

The Quadrant of Altitude, or Poſition.

III.

The Brazen Meridian.

IV.

The Index, and Hour-Circle.

V.

V.

The Horizon, or wooden Frame.

Plate IV. Fig. 1. The Globe itſelf repreſents the natural Poſition of the Heavens, and demonſtrates any Propoſition relating to the Sphere, with regard to the apparent Motion of the Sun, Moon, or Stars, as they are ſeen from the Earth.

Fig. 2. The Brazen Meridian is divided into four Parts, each containing 90 Degrees, or the fourth Part of a great Circle. The Globe (ſupported by its Axis) is turned within this Meridian, which elevates and depreſſes it to any given Latitude.

Fig. 3. The Hour-Circle is divided into the twenty-four Parts of a natural Day, commonly called Hours; each of which is ſubdivided into Halves and Quarters: the Center of it is the Axis or Pole of the viſible Hemiſphere, on which is fixed the Index.

Fig. 4. The Quadrant of Altitude, or of Poſition, is divided into 90°, *i. e.* 90 Degrees, and moves upon the Meridian, to any Situation required on the Surface of the Globe.

Fig. 5. The Horizon, or upper Part of the wooden Frame, is divided into a perpetual Calendar, with Degrees, *&c.* circumſcribing the whole Globe, ſhewing the Day of the Month, the Sun's Place in the Zodiack, the

the fixed Feaſts, and the Points of the Compaſs, *&c.*

But to be more particular. All Aſtronomers, both ancient and modern, have either imagined or actually delineated upon the Globe, ten principal Points, and the like number of Circles.

The principal Points are theſe. Plate V. Fig. 1.

Firſt, The two *Poles* of the World, (PP) which are two Points, directly oppoſite to one another, about which, the Stars or the Earth apparently ſeem to turn. That on the North-ſide of the Equator (viſible to us) is called the North Pole, or *Arctic*, (from ἄρκτος, a Bear.) That on the South-ſide, which is inviſible to us, and can only be ſeen to the Inhabitants of the Southern Hemiſphere, is call'd the South or Antarctic Pole, (from being diametrically oppoſite to the other.) The Line imagined to paſs from one Pole to the other, is called the *Axis*, being common to the whole Sphere both of the Earth and Heavens.

Secondly, The *Poles* of the *Ecliptic*, (EE) which are two Points, exactly oppoſite to each other, and diſtant from the Poles of the World, nearly 23°, 30′; *i. e.* form an Angle with it equal to the Inclination of the Ecliptic and Equinoctial. One of theſe is inviſible to us, being depreſſed below the Horizon all the Year.

Thirdly, The two *Equinoctial Points*, (♈ ♎) which are generally repreſented by the Center of the Sun: one at his Ingreſs into the Spring, on, or about the 10th of *March*; the other on, or near, the 13th Day of *September*, at his Ingreſs into the Autumnal Seaſon. In both theſe Points, the Sun makes Night and Day of equal Lengths, to all the Parts of the World.

Fourthly, The two *Solſtitial Points*, (♋ ♑) *Cancer* and *Capricorn*, of which the firſt is repreſented by the Sun's Center at his Ingreſs into the Summer Seaſon, on or near the 11th of *June*, making to us the longeſt Day; but to the Southern Inhabitants the ſhorteſt; and conſequently to them the longeſt Night, and to us the ſhorteſt. The other has his Ingreſs into the Winter Seaſon, on or about the 12th Day of *December*: at which time, we, in the North Part of the World, have the ſhorteſt Day, and they in the South the longeſt; the Nights being the reverſe of what they are deſcribed above.

Laſtly, The *Poles* of the *Horizon* (ZN:) which are two Points in the Heavens, diametrically oppoſite; whereof the one, which is directly over our Heads, is called the *Zenith*, (or Vertical Point) the other, which lies under our Feet, is called the *Nadir*.

The

The ten principal Circles are as follow.

The firſt is the *Equinoctial* (ÆQ.) This Circle (which divides the Heavens into two equal Parts) is divided (as was ſaid before) into 360 equal Parts, call'd Degrees; being number'd from 10 on to 360. On theſe is counted the right, or oblique Aſcenſion of the Sun, Moon, or Stars.

The ſecond is the *Meridian* (MMMM,) ſo call'd, from repreſenting the Midheaven of the Place where we are; becauſe, when the Sun arrives at that Point, 'tis Noon or Mid-Day. This great Circle then, which paſſeth through the Poles, the Zenith, and Nadir, is divided into four Quadrants of 90 Degrees each; two of which commence at the Equator, or Equinoctial, and are number'd, with 10, 20, *&c.* to 90°, towards each Pole; the other two are number'd, in like manner, from the Poles towards the Equator, or Equinoctial. By the former we compute the Latitude of Places and the Declination of the heavenly Bodies; by the latter, the Elevation of the Pole, of any given Place, above the Horizon.

The third is the *Horizon* (NS) which divides the viſible Hemiſphere from the inviſible; and is repreſented by the Wooden Frame.

The fourth is the *Ecliptic* (AC,) which is a great Circle croſſing the Equinoctial in two Points, call'd *Aries* and *Libra*; one half of which declines to the North, the other to the South 23° 30′. On this Circle is counted the Longitude of the Sun, and Stars, *&c.* The Circumference of it is divided into 12 equal Parts, call'd Signs; each containing 30 Degrees, through which the Sun, apparently, performs his Annual Courſe. This Line is imagin'd to lie in the middle of a Zone, or Girdle, 18 Degrees in breadth, call'd the Zodiack; in which Space, the Planets, *viz.* the *Moon*, *Jupiter*, *Mars*, &c. make their Revolutions. Hence, the 12 Conſtellations likewiſe which lie in this Path, are call'd Signs of the Zodiack, being mark'd and nam'd, upon the Globe, as follow.

Order.	Name.	Character.	
1	*Aries*	♈	
2	*Taurus*	♉	The Spring Signs.
3	*Gemini*	♊	
4	*Cancer*	♋	
5	*Leo*	♌	The Summer Signs.
6	*Virgo*	♍	
7	*Libra*	♎	
8	*Scorpio*	♏	The Autumn Signs.
9	*Sagittarius*	♐	

10.

10. *Capricornus* ♑
11. *Aquarius* ♒ } The Winter Signs.
12. *Piſces* ♓

It may be proper here to obſerve, that the Conſtellations, ſince they were firſt fixed and taken notice of, have conſiderably alter'd their Poſitions in the Heavens, and ſtill continue to do ſo, at the Rate of 50″ and 40‴ in a Year *. This is call'd the Preceſſion of the Equinox, or the Motion of the Stars, apparently, from Weſt to Eaſt: one Revolution of which, through the 12 Signs of the Zodiac, or round the Ecliptic Poles, will require 25920 Years.

And hence it is, that the two Equinoctial Points, which were fix'd, at the Birth of *Chriſt*, in the beginning of the Conſtellations *Aries* and *Libra*, have alter'd their Poſitions, or Places, among the Stars, almoſt a whole Sign, and ſeem to have gone backwards: So that, at this time, the Conſtellation or Body of Stars call'd *Aries*, appears in the Sign *Taurus*, and *Taurus* in *Gemini*, &c. which is the Reaſon that our Aſtronomers of late have changed their Titles from the fix'd Order of Signs, to that of Conſtella-

* By this Annual Inequality (the Quantity being known) the Stars Places in Longitude may be rectified to any Time paſt, preſent, or to come. The new Contrivance which Mr. *Senex* has added to the Celeſtial Globe for this purpoſe, will make all Obſervations and Calculations of this kind very plain and obvious.

tions in the Zodiac, and expreſs the Sign upon the Globe, by the Character only.

The fifth and ſixth are the *Colures* (APCP and P♈P) which are great Circles, or Meridians, that paſs through the Poles of the World, and, croſſing each other at right Angles, divide the Year into four Seaſons, *viz.* Spring, Summer, Autumn, and Winter. That which paſſeth thro' the Equinoctial Points, or the Beginnings of *Aries* and *Libra*, is call'd the *Equinoctial Colure*: The other, which paſſeth thro' the Solſtitial Points, or the Beginnings of *Cancer* and *Capricorn*, is call'd the *Solſtitial* Colure.

The ſeventh and eighth are the *Tropics* (IC and AD) which are leſſer Circles, parallel to the Equinoctial, being 23° 30′ equally diſtant on each Side. That on the North-ſide is call'd the Tropic of *Cancer*, in which the Sun, entering the Sign *Cancer*, makes his greateſt Declination to the northward: the other, on the South-ſide, is call'd the Tropic of *Capricorn*, to which, when the Sun arrives, he enters *Capricorn*, and makes his greateſt Declination to the ſouthward.

The laſt are the two *Polar Circles* (EK and GE) which are deſcribed by the Revolution of the Ecliptic Poles, round the Poles of the World. One of them is call'd the *Arctic* Circle, circumſcribing the North Pole: the other is call'd the *Antarctic* Circle, and circumſcribes the South Pole.

Theſe

Theſe are the chief Circles, both of the Celeſtial and Terreſtrial Globes; being the ſame with the principal Parts of the *Armillary* Sphere. Beſides theſe, there are divers other Circles, which are not delineated upon the Globes; being ſuch only as are apprehended by the Imagination. Of which kind are the *Azimuths* and *Almicanthers*, &c. Such as AI and ZH.

Now the latter, which are ſmall Circles parallel to the Horizon, and are imagin'd to paſs thro' every Degree and Minute of the Meridian from the Horizon to the Zenith, are commonly call'd, Circles of Altitude. The *Azimuths* are great Circles, intercepting one another, at the *Zenith* and *Nadir*. They cut the Horizon at right Angles, and are properly call'd Vertical Circles; being as infinite in number as the former. Plate V. Fig. 3. Fig. 2.

CHAP. III.

Of the CONSTELLATIONS, *or* FIGURES *drawn upon the* Celeſtial GLOBE.

HAVING in the laſt Chapter deſcribed all the real and imaginary Circles on this Globe, the next thing is, to give a Deſcription of the *Aſteriſms*, or Conſtellations, and of the number of Stars belonging to each; which, according to the *Britannic* Catalogue, are in the following Order, *&c.*

Vid. *Flamſted's* Hiſtoria Cæleſtis.

	Order.	Names.	N° of Stars.
Conſtellations in the Zodiac.	1	*Aries*	65
	2	*Taurus*	135
	3	*Gemini*	89
	4	*Cancer*	72
	5	*Leo*	94
	6	*Virgo*	89
	7	*Libra*	47
	8	*Scorpio*	49
	9	*Sagittarius*	50
	10	*Capricornus*	51
	11	*Aquarius*	99
	12	*Piſces*	109

Order.

Order.	Names.	N° of Stars.	
13	*Andromeda*	84	Conſtellations in the North Hemiſphere.
14	*Triangulum*	24	
15	*Perſeus*	67	
16	*Auriga.*	68	
17	*Coma Berenices*	40	
18	*Boötes*	55	
19	*Corona Borealis*	21	
20	*Serpentarius*	59	
21	*Serpens*	69	
22	*Aquila & Antinous*	70	
23	*Sagitta*	23	
24	*Delphinus*	18	
25	*Equulus*	10	
26	*Pegaſus*	93	
27	*Caſſiopea*	56	
28	*Urſa Major*	215	
29	*Alcides*	95	
30	*Lyra*	19	
31	*Cygnus*	107	
32	*Cepheus*	35	
33	*Urſa Minor*	14	
34	*Draco*	49	
35	*Cetus*	78	Conſtellations in the South Hemiſphere.
36	*Eridanus*	68	
37	*Orion*	80	
38	*Lepus*	19	
39	*Canis* Major	32	
40	*Canis* Minor	17	
41	*Argo Navis*	25	

Order.

Order.	Names.	N° of Stars.	
42	*Hydra*	68	Conſtellations in the South Hemiſphere.
43	*Crater*	11	
44	*Corvus*	10	
45	*Lupus & Centaurus*	13	
46	*Piſcis Auſt.*	16	

In all, properly, 49 Conſtellations, containing 2677 Stars; which are rectified by the late Mr. *Flamſted* to the Beginning of the Year 1690.

All theſe Stars are expreſſed upon the Globe, in different Degrees of Magnitude, nearly as they appear to us in the Heavens; being accordingly divided into ſeven Claſſes, diſtinguiſhed in this Manner: The brighteſt and largeſt of them are call'd Stars of the Firſt Magnitude; the next inferior to them in Bigneſs and Brightneſs, are call'd Stars of the Second Magnitude; and ſo on to thoſe of the Seventh: All which are repreſented on the Globe in their proper Magnitudes, according to a little Table engraved thereon, intitled *Stellarum Magnitudines*. Beſides the obſcure or teleſcopic Stars, that make up the *Via Lactea* and others that appear in *Caſſiopea*, *Hercules*, &c. there are alſo ſeveral other Conſtellations drawn upon the Celeſtial Globe, which are ſeen only to the Inhabitants of the Southern Hemiſphere, and are not therefore mention'd by Mr. *Flamſted*,

Flamſted, as not having had an Opportunity to obſerve them. Theſe were firſt formed into Conſtellations by the *Arabians*, &c. and have ſince been improv'd by Dr. *Halley*'s Obſervations at the Iſland of St. *Helena*, being in number 15; which, together with the former, compleat the Catalogue of the Antients, as deliver'd down to us by *Ptolemy* and *Tycho*.

Their Names are as follows, *viz.*

1	*Phœnix*	containing 13 Stars.
2	*Grus*	14
3	*Indus*	12
4	*Pavo*	14
5	*Apus*	11
6	*Triangulum*	5
7	*Muſca*	4
8	*Robur Caroli*	13
9	*Toucan*	9
10	*Chamæleon*	10
11	*Hydrus*	9
12	*Piſcis Volans*	7
13	*Columba Noachi*	10
14	*Ara*	9
15	*Xiphias*	7

All theſe lie within the Diſtance of 50 Degrees from the South Pole, and conſequently are below our Horizon, and to us inviſible.

Hevelius

Hevelius, likewiſe, and others have formed ſeveral new Conſtellations out of ſuch Stars as lay betwixt the old ones; ſuch are the

1 *Lacerta*, or *Stellio.*
2 *Ramus* and *Cerberus.*
3 *Chara.*
4 *Aſterion.*
5 *Cor Caroli.*
6 *Leo Minor.*
7 *Lynx.*
8 *Camelopardalus.*
9 *Muſca.*
10 *Triangulum Minor.*
11 *Vulpecula.*
12 *Anſer.*
13 *Scutum Sobieſci.*
14 *Mons Mænalus.*
15 *Monoceros.*
16 *Sextans Uraniæ.*
17 *Cruſero.*

Making in all, as they are now drawn on the Celeſtial Globe, 81. To which may be added, for the better Regulation of thoſe Stars that are yet unform'd,

Arca Noæ.
Oculus Uraniæ.
Paradiſus.
Sceptrum Britannicum.
Turris Babelonica.
Orbis Regius.
Pſittacus.
Sciurus.

The

The firſt is a Knot of five Stars, two of which are of the third, one of the fifth, and two of the ſixth Magnitude; they are placed near the Head of *Lepus* below *Orion*, betwixt him and the North Fin of *Cetus* (the Whale) oppoſite to *Eridanus*.

The ſecond is a bright Star of the fourth Magnitude, between *Boötes* and *Mons Mænalus*.

The third is a Knot of ſmall Stars, ſituated below *Taurus*, above the River *Eridanus*, between *Orion* and *Cetus*; two of which are of the fifth, ſeven of the fourth, and two of the ſixth Magnitude; in all eleven.

In the fourth, are four ſmall Stars; two of the fourth, and two of the ſixth Magnitude: they are placed, nearly in the middle, between *Pegaſus* and the *Dolphin*.

The fifth is a bright Knot of Stars, between *Corvus* and the Right Leg of *Virgo*. They are in number twelve, *viz.* two of the fourth, three of the fifth, ſix of the ſixth, and one of the ſeventh Magnitude.

The ſixth is a Knot of ten Stars, near the Fore-feet of *Lupus*, between *Libra* and *Centaurus*; one of which is of the third, two of the fifth, and ſeven are of the ſixth Magnitude.

The ſeventh conſiſts of two bright Stars of the fourth Magnitude, near the hinder Foot

Foot of *Leo*, betwixt the *Cup* and the *Sextans Uraniæ*.

The laſt is a Knot of ſix Stars, whereof four are of the fifth, and two of the ſixth Magnitude.

All theſe are delineated apart upon the Modern Globes, and would be improperly affixed, or adjoined, to any of the former Figures, or Conſtellations.

We ſhould not likewiſe omit two other Stars; one of the fourth, the other of the fifth Magnitude, placed betwixt the Hind Foot of *Leo* and the *Sextans Urania*: Beſides three more, near the *Milky Way*, below the Tail of *Lyra*, betwixt *Anſer* and *Cerberus*, near the Tail of *Aquila*, two of the fourth and one of the fifth Magnitude: which are not known at preſent by any particular Name.

In the following Table the Reader will have in one View, the number of Conſtellations, both antient and modern, together with the reſpective Numbers and Magnitudes of the Stars that conſtitute them.

The TABLE begins.

N° of Stars.	Names of the Conſtellations.	Magnitudes. I	II	III	IV	V	VI	VII	
49	Draco		1	7	8	10	20	3	
12	Urſa Minor		2	1	4	3	2		
40	Cepheus			3	7	10	16	4	
52	Caſſiopea			5	7	7	27	6	
12	Lacerta Stellio				3	5	4		
73	Cygnus		1	5	15	20	32		Northern Conſtellations near the Pole.
24	Lyra	1		3	2	8	10		
9	Ramus & Cerberus				3	1	5		
92	Hercules			12	12	28	38	2	
11	Corona Septentrionalis		1		6	3	1		
53	Boötes	1		7	10	12	18	5	
11	Chara				1	4	4	2	
13	Aſterion					3	5	5	
3	Cor Caroli		1				2		
24	Coma Berenices				6	8	8	2	
105	Urſa Major		5	5	16	30	43	6	
20	Leo Minor			1	6	5	7	1	

The remarkable Stars.

In *Draco* 3, two in his Head, which paſſes over our Zenith, and one in his Tail mark'd (α); which was the Pole Star at the Creation. In *Urſa Minor* 2, one in his Tail, which is the preſent Pole Star, another in his Neck, call'd *Kochab*. In *Cepheus* 4, one in his Crown, (ε) one in his Right Arm, (α) one in his Left Foot, (γ) and a bright one in his Girdle, (ζ). In *Caſſiopea* 5, one call'd *Schedar*, and four other bright ones, commonly call'd her *Chair*. In *Lacerta Stellio* 0. *Cygnus* the whole Form: in particular, one in the Tail call'd *Arided*, and one in the *Neb. Albireo*. In *Lyra* 4, one in the Left Wing, mark'd α, and three in the *Harp*. In *Ramus* and *Cerberus* 0. In *Hercules* 3, one in his Forehead, call'd *Ras Algethi*, one in his Left Arm, call'd *Marſic*, and one in his Right Arm, call'd *Maaſym*, in the Crown a bigger one. In *Boötes* 2, one near his Left Thigh call'd *Arcturus*, and one in his Girdle call'd *Mirach*. In *Chara* 0. In *Aſterion* 0. In *Cor Caroli* a bright one. In *Coma Berenices* 0. In *Urſa Major* ſeven bright ones, commonly call'd *Charles's Wain*, one of which, the Pointer to the Pole, is call'd *Dubhe*, and another *Aliath*. In *Leo Minor* 0.

The

The TABLE continued.

	N°	Names.	Magnitudes. I	II	III	IV	V	VI	VII	
	55	Lynx			1	8	21	20	5	
	23	Camelopardalus				5	7	11		
	46	Auriga	1	1	1	9	9	22	3	
	67	Perſeus	1	1	5	10	14	27	9	
	6	Muſca			1	2	2		1	
	5	Triangulum Minor						2	3	
Northern Conſtellations near the Ecliptic.	10	Triangulum Major				3	1	4	2	
	66	Andromeda		3	2	10	16	35		
	81	Pegaſus		3	4	9	11	50	4	
	12	Equulus				4	1	6	1	
	18	Delphinus			6		2	9	1	
	29	Vulpecula				6	11	10	2	
	10	Anſer					2	7	1	
	13	Sagitta				4	1	8		
	29	Aquila	1		5	1	4	18		
	34	Antinous		{	4	2	7	13	6	S.D.
				{	1			1		N.
	8	Scutum Sobieſci				2	3	2	1	S.D.

The remarkable Stars.

In *Lynx* 0. In *Camelopardalus* 0. In *Auriga* 3, one in his Right Shoulder call'd *Capella*, one on his Head mark'd (ϑ), and one on his Left Arm (ε) In *Perſeus* ſeven, *viz.* two on his Left Side, one of which is call'd *Algenib*, two on his Left Arm, two on his Right Foot, and one in the Head of *Meduſa* call'd *Algol*. In *Muſca* 0. In the *Triangles* 0. In *Andromeda* 3, *viz.* her Right Foot *Almaack*, on her Head (α), and Zone (ε). In *Pegaſus* 4, his Mouth *Enif*, his Left Leg *Scat Alpheras*, the Pinion of his Wing *Markab*, and its Tip (γ). In *Equulus* 0. In the *Dolphin* 6, four in the Head, and two in the Tail. In the *Fox* 0. In *Anſer* 0. In *Sagitta* 0. In *Aquila* 6, three in his Breaſt, two in his Tail, and one in his Left Wing call'd *Atair*. In *Antinous* 6, *viz.* on his Right Hand, Shoulder and Dart, a bright one in his Breaſt, Left Foot, and Right Knee. In *Scutum Sobieſci* 0.

The

The TABLE continu'd.

N°	Names.	Magnitudes.							
		I	II	III	IV	V	VI	VII	
67	Serpentarius ——		1	6	12	17	20	11	
45	— of South Declination ——			4	4	15	17	5	
19	— of which are of S. Latitude ——				1	5	8	5	
50	Serpens ——		1	7	6	5	27	4	
15	— of S. Declination			2	3	1	9		
11	Mons Mænalus——				1		7		
	North Constellations in all								
1243	37	5	21	92	200	291	541	93	
100	Whereof are of S. Declination ——			10	11	26	41	12	
19	— of S. Latitude —				1	5	8	3	
46	Aries ——		1	1	3	5	24	12	
41	— of N. Latitude—		1	1	2	4	22	11	
5	— of S. Latitude —				1	1	2	1	North Signs.
109	Taurus ——	1	1	3	9	24	27	44	
46	— of N. Latitude—		1		2	13	10	20	
63	— of S. Latitude —	1		3	7	11	17	22	

The remarkable Stars.

In *Serpentarius* 7, *viz.* on his Left Shoulder, Right and Left Hand, Left Foot, Left Knee, Right Ham, and one in his Ear call'd *Ras Alhague*. In *Serpens* 8, *viz.* in the Head *x*, *γ*, *ζ*, *i*, *l*, in the Tail *η*, *θ*, and near the Mountain *α*. In *Mons Mænalus* o. In *Aries*, two in his Head, one mark'd (*x*), the other (*ζ*). In *Taurus* 5, his South Eye, call'd *Aldebaran*, a Knot of 12 Stars on his Shoulder, call'd the *Pleiades*, his North and South Horn, Left Leg, and, near his North Eye, the *Hyades*.

The TABLE continu'd.

	N°	Names.	Magnitudes.						
			I	II	III	IV	V	VI	VII
	94	Gemini	1	2	4	8	13	32	34
	54	— of North Latitude	1	1	1	5	10	20	16
	40	— of South Latitude		1	3	3	3	12	18
	75	Cancer				6	8	40	21
	45	— of North Latitude				3	6	24	12
North Signs.	30	— of South Latitude				3	2	16	9
	91	Leo	2	2	6	13	11	38	19
	52	— of North Latitude	2	2	5	7	1	26	9
	39	— of South Latitude			1	6	10	12	10
	3	— of South Declination				1	2		
	93	Virgo	1		3	11	24	44	8
	68	— of North Latitude			5	9	17	31	6
	25	— of South Latitude	1			2	7	13	2
	45	— of South Declination	1			8	10	21	5
South Signs.	33	Libra		2	1	8	3	12	7
	2	— of South Latitude				1		1	
	31	— of North Latitude		2	1	7	3	11	7

The remarkable Stars.

In *Gemini* 3, one in the Head of the North Twin call'd *Caſtor*, another in the Neck of the South One, call'd *Pollux*, and a bright Star in the Left Foot of the ſame. In *Cancer* 2, one near his Heart call'd *Præſepe*, and one in the great South Claw, call'd *Acubene*. In *Leo* 4, *viz.* on his Neck, and Back, his Tail, call'd *Deneb*, and his Heart, call'd *Regulus*. In *Virgo* 6, one in the Ear of Corn, call'd *Ariſta*, one in her Left Elbow, call'd *Vindemiatrix*, on her Girdle, Right and Left Foot, and the Pinion of her Left Wing. In *Libra* 3, one in the South Scale, call'd *Zubenaſchemali*, one in the North Scale, call'd *Zubenelgenubi*, and one, the brighteſt of the ſix ſouthward, call'd *Zubenſlatzrabi*.

The

The TABLE continu'd.

N°	Names.	Magnitudes.							
		I	II	III	IV	V	VI	VII	
44	Scorpio	1	3	6	14	5	14	1	
35	— of South Latitude	1	2	6	11	2	12	1	
9	— of North Latitude		1		3	3	2		
48	Sagittarius		1	5	9	11	21	1	
24	— of S. Latitude —			1	3	3	17		
24	— of N. Latitude —		1	4	6	8	4	1	
58	Capricornus			2	5	9	39	3	Southern Signs.
35	— of S. Latitude —			1	2	2	16	2	
23	— of N. Latitude —			1	3	7	23	1	
93	Aquarius			4	7	28	48	6	
52	— of S. Latitude —			1	3	21	24	3	
41	— of N. Latitude —			3	4	7	24	3	
2	— of N. Declination						2		
110	Piſces			1	7	28	58	16	
26	— of S. Latitude —			1	1	9	11	4	
84	— of N. Latitude —				6	19	47	12	
93	— of N. Declination			1	6	23	47	16	
894	In all belonging to the Signs —	6	12	38	100	169	397	172	

The remarkable Stars.

In *Scorpio* 3, the Head, and one in the Tail call'd *Leſath*; alſo the Heart, *Antares*. In *Sagittarius* 6, one in his Bow (ε), his Head, Right Shoulder, and Bow Hand, and Arm. In *Capricornus* 2, one in his Head (ζ), and one in his Tail, *Algedi*. In *Aquarius* 4, one in his Right Shoulder, two on his Left Arm, and one in his Left Leg call'd *Scheat*. In *Piſces* only one mark'd (α).

The TABLE continu'd.

	N°	Names.	Magnitudes.						
			I	II	III	IV	V	VI	VII
	518	Of which are North from the Ecliptic	3	8	18	53	88	250	98
	376	And to the South	3	4	20	57	81	147	74
	555	Of North Declination	4	6	18	47	96	233	149
	339	Of South Declination	2	6	20	53	73	164	23
	93	Orion	2	4	3	19	15	42	8
	22	— of S. Declination —	1	3	3	6	6	3	
	71	— of N. Declination—	1	1		13	9	39	8
Southern Conſtellations.	25	Lepus			4	9	4	8	
	72	Eridanus	1		10	24	19	18	
	2	— of N. Declination—				2			
	80	Cetus		2	8	13	10	40	7
	12	— of N. Declination—		1	1	5	2		3
	15	Piſces Auſt.	1		2	9	2	1	
	12	Corona Auſt.				1	3	8	
	9	Ara			1	6	1	1	

The remarkable Stars.

In *Orion* 9, his Right Shoulder *Bellatrix*, his Left Shoulder *Batelgous*, and three in his Girdle, his Right Foot *Rigel*, one towards his Right Hand, and his Left Knee (*x*). In *Lepus* the whole Form, and two bright ones more, one in the Roof, the other in the firſt Window of *Noah*'s *Ark*. *Eridanus* the whole, particularly one near the *Phœnix* call'd *Acharnar*. In *Cetus* 10, *viz.* his Mouth, one in his Jaw-bone *Menkar*, one in his Tail *Kaitos*, three bright ones on his Body, one call'd *Batecketos*, one upon his Shoulder, and ſeveral on his Breaſt. *Piſces Auſt.* the whole, particularly one call'd *Fomalhaut*. In *Ara* 1, near the Feſtoon. In *Corona Auſt.* 0.

The

The TABLE continued.

N°	Names.	Magnitudes.							
		I	II	III	IV	V	VI	VII	
36	Lupus			3	6	18	9		
36	Centaurus	2	6	6	14	8			
8	Corvus			2	2	2	2		
11	Crater				8	2	1		
4	Sextans Uraniæ						2	2	
53	Hydra		1	3	14	13	16	6	
11	— of North Declination				6	4	1		Southern Conſtellation.
14	Canis Minor N. D.	1		1		2	9	1	
32	Monoceros			1	10	10	11		
6	— of North Declination				5	1			
48	Argo Navis	1	6	11	13	14	3		
29	Canis Major	1	5	1	4	10	5	3	
10	Columba Noachi		2		1	6	1		
13	Phœnix		1	5	5		2		
14	Grus		2	1	2	9			
12	Indus				4	6	2		
14	Pavo		1	3	5	4	1		
11	Apus				4	3	4		

The remarkable Stars.

In *Lupus* 3, two of which are in his hind Foot, the other amongſt the unform'd (now the Royal Orb.) In *Centaurus* 8, one on his Right Shouder (ι), one on his Left (ζ), his Left Arm (κ), two in his Fore Feet, two on the Horſe's Body, and one (λ) near the Tail of *Lupus*. The 4 under the Horſe's Belly, are call'd the *Croſiers*, in form of a Diamond, or *Lozenge*. In *Corvus* 2, one in his Left Foot, the other in his Right Wing, call'd *Algorab*. In *Crater* 0. *Sextans Uraniæ* 0. In *Hydra* 4, his Heart *Alphard*, his Head, and two bright ones in his Tail. In *Canis Minor* 2, his Neck (ϵ), and one in his Flank, *Procyon*. *Monoceros* 1 bright one on his Belly. In *Argo Navis* 17, three bright ones in the Stern (μ ι κ), three on the Deck, ſeven on the Keel, and three in the Waves, one call'd *Canopus*, another *Markeb*. In *Canis Major* 6, one in his Mouth *Sirius*, and five others in his Tail, Flank, Fore and Hind Foot. In the *Dove* 2, on the Body. In the *Phœnix* 1, on the Head. In *Grus* 3, one in the Head, one in the Right Wing, and one on the Body. *Indus* 0. In *Pavo* 4, one on his Eye, and three bright ones on his Body. *Apus* 0.

The TABLE continu'd.

	N°	Names.	Magnitudes.						
			I	II	III	IV	V	VI	VII
	518	Of which are North from the Ecliptic	3	8	18	53	88	250	98
	376	And to the South	3	4	20	57	81	147	74
	555	Of North Declination	4	6	18	47	96	233	149
	339	Of South Declination	2	6	20	53	73	164	23
	93	Orion	2	4	3	19	15	42	8
	22	— of S. Declination —	1	3	3	6	6	3	
	71	— of N. Declination—	1	1		13	9	39	8
Southern Conſtellations.	25	Lepus			4	9	4	8	
	72	Eridanus	1		10	24	19	18	
	2	— of N. Declination—				2			
	80	Cetus		2	8	13	10	40	7
	12	— of N. Declination—		1	1	5	2		3
	15	Piſces Auſt.	1		2	9	2	1	
	12	Corona Auſt.				1	3	8	
	9	Ara			1	6	1	1	

The remarkable Stars.

In *Orion* 9, his Right Shoulder *Bellatrix*, his Left Shoulder *Batelgous*, and three in his Girdle, his Right Foot *Rigel*, one towards his Right Hand, and his Left Knee (*x*). In *Lepus* the whole Form, and two bright ones more, one in the Roof, the other in the firſt Window of *Noah*'s *Ark*. *Eridanus* the whole, particularly one near the *Phœnix* call'd *Acharnar*. In *Cetus* 10, *viz.* his Mouth, one in his Jaw-bone *Menkar*, one in his Tail *Kaitos*, three bright ones on his Body, one call'd *Batecketos*, one upon his Shoulder, and ſeveral on his Breaſt. *Piſces Auſt.* the whole, particularly one call'd *Fomalhaut*. In *Ara* 1, near the Feſtoon. In *Corona Auſt.* 0.

The

The TABLE continued.

N°	Names.	Magnitudes.							
		I	II	III	IV	V	VI	VII	
36	Lupus			3	6	18	9		
36	Centaurus	2	6	6	14	8			
8	Corvus			2	2	2	2		
11	Crater				8	2	1		
4	Sextans Uraniæ						2	2	
53	Hydra		1	3	14	13	16	6	
11	— of North Declination-				6	4	1		Southern Conſtellation.
14	Canis Minor N. D.	1		1		2	9	1	
32	Monoceros			1	10	10	11		
6	— of North Declination				5	1			
48	Argo Navis	1	6	11	13	14	3		
29	Canis Major	1	5	1	4	10	5	3	
10	Columba Noachi		2		1	6	1		
13	Phœnix		1	5	5		2		
14	Grus		2	1	2	9			
12	Indus				4	6	2		
14	Pavo		1	3	5	4	1		
11	Apus				4	3	4		

The remarkable Stars.

In *Lupus* 3, two of which are in his hind Foot, the other amongſt the unform'd (now the Royal Orb.) In *Centaurus* 8, one on his Right Shouder (ι), one on his Left (ζ), his Left Arm (κ), two in his Fore Feet, two on the Horſe's Body, and one (λ) near the Tail of *Lupus*. The 4 under the Horſe's Belly, are call'd the *Croſiers*, in form of a Diamond, or *Lozenge*. In *Corvus* 2, one in his Left Foot, the other in his Right Wing, call'd *Algorab*. In *Crater* 0. *Sextans Uraniæ* 0. In *Hydra* 4, his Heart *Alphard*, his Head, and two bright ones in his Tail. In *Canis Minor* 2, his Neck (ϵ), and one in his Flank, *Procyon*. *Monoceros* 1 bright one on his Belly. In *Argo Navis* 17, three bright ones in the Stern (μ ι κ), three on the Deck, ſeven on the Keel, and three in the Waves, one call'd *Canopus*, another *Markeb*. In *Canis Major* 6, one in his Mouth *Sirius*, and five others in his Tail, Flank, Fore and Hind Foot. In the *Dove* 2, on the Body. In the *Phœnix* 1, on the Head. In *Grus* 3, one in the Head, one in the Right Wing, and one on the Body. *Indus* 0. In *Pavo* 4, one on his Eye, and three bright ones on his Body. *Apus* 0.

The TABLE continu'd.

	N°	Names.	Magnitudes.						
			I	II	III	IV	V	VI	VII
	5	Triangulum —		1	2		2		
	4	Muſca —				2	2		
South	13	Robur Caroli —		1	2	6	4		
Conſtella-	9	Toucan —			4	2	3		
tions	10	Chamæleon —					9	1	
	9	Hydrus —		1	2	2	3	1	
	7	Piſces Volans —					6	1	
	7	Xiphias —			2	2	1	2	
	715	South Conſtellation in all 31,	9	33	77	187	191	191	27
	116	Whereof are of North Declination —	2	2	2	31	18	49	12
	2852	Total 80 *	20	65	208	487	651	1129	292
	1038	Of S. Declination	9	36	104	220	272	347	50
	1814	Of N. Declination	11	29	104	267	379	782	252
	1110	Of S. Latitude —	12	37	97	235	277	346	106
	1742	Of N. Latitude —	8	28	111	252	374	783	186

The remarkable Stars.

In *Triangulum* 3, on the Side, and the two South Angles. *Muſca* 0. In *Robur Caroli* 3, one in the Root, one in the Trunk, and one in the North Bough. In *Toucan* 4, two on the Body, one in the Head, and one in the Beak. In *Chamæleon* 0. In *Hydrus* 3, one in the Head, and two in the Tail. *Piſces Vol.* 0. *Xiphias* 2, one in and one near the Tail.

* If the *Cruſero* or *Croſiers*, which ſometimes makes a part only of *Sagittarius*, be made a diſtinct Conſtellation, then the Number will be 81, as in Page 28.

CHAP.

CHAP. IV.

Of the Terreſtrial GLOBE.

THE Terreſtrial Globe is an artificial, ſpherical Body, like the Cæleſtial, made to repreſent the Diſpoſition of Land and Water upon the Earth we inhabit. Beſides the Ecliptic, the Equinoctial or Equator, the Tropics, Polar Circles, *&c.* which it has in common with the Celeſtial Globe, there are others peculiar to it, being of Uſe only in Geography; ſuch are the *Meridians*, *Parallels of Latitude*, and *Rhombs*. Plate VI. VII.

The *Meridians* are great Circles paſſing through every Tenth or Fifteenth Degree of the Equator, and interſect one another at the Poles. They are generally, when repreſented in Maps, call'd Circles of Longitude. Fig. 1.

The *Parallels of Latitude*, are leſſer Circles, drawn at equal Diſtances from the Equator, and paſs through every Tenth Degree of the Univerſal or Brazen Meridian. They are of Uſe in diſtinguiſhing the Length of Day, *&c.* as will be ſhewn hereafter. Fig. 2.

The *Rhombs* are infinite, ſpiral Lines, in number 14; all variouſly winding round the Globe, at equal Angles from the Meridians Fig. 3.

and from each other, till, drawing near the Poles, they become confus'd, and loſe themſelves. However, they are of all other Lines whatſoever, the moſt ſurprizing; having properly no Beginning or End; yet they have a Middle, are limited, and may be equally divided. They continually advance to the Polar Points, yet can never touch them; and any two of them, of the ſame Direction, may continually approach, but never meet. The greateſt Diſtance of any two of them is in the Equator, which conſequently, is their mathematical Middle. They may alſo be imagin'd to begin every where, except in the two Poles, being all of them of the ſame kind, and infinite in number.

Theſe different Interſections, of the Meridians and Parallels, form 32 oblique Directions, commonly call'd *Points of the Compaſs*; whereof the North Point is generally diſtinguiſh'd by a *Flower-de Luce*; the reſt are nam'd and number'd, as in the following Table.

The

NORTH
North by East
North Nor: East
Nor: East by North
NORTH EAST
Nor. East by East
East North East
East by North
EAST
East by South
East South East
South East by East
SOUTH EAST
South East by South
South So: East
South by East
SOUTH
South by West
South So. West
South West by South
SOUTH WEST
South West by West
West South West
West by South
WEST
West by North
West North West
Nor. West by West
NORTH WEST
North West by North
North Nor. West
North by West

A TABLE of the *Angles* which every Point of the Compaſs makes with the *Meridian*.

NORTH.		D. M.		SOUTH.
N. by E. or N. by W.	1	11 : 15	1	S. by E. or S. by W.
N. N. E. or N. N. W.	2	22 : 30	2	S. S. E. or S. S. W.
N. E. by N. or N. W. by N.	3	33 : 45	3	S. E. by S. or S. W. by S.
N. E. or N. W.	4	45 :	4	S. E. or S. W.
N. E. by E. or N. W. by W.	5	56 : 15	5	S. E. by E. or S. W. by W.
E. N. E. or W. N. W.	6	67 : 30	6	E. S. E. or W. S. W.
E. by N. or W. by N.	7	78 : 45	7	E. by S. or W. by S.
EAST.		or		WEST.

CHAP.

CHAP. V.

Of the Diviſion of the Terreſtrial GLOBE.

Plate VIII. NOW the Terraqueous or Terreſtrial Globe, conſiſting of Land and Water, is divided by Geographers, firſt into *Continents* A. *Iſthmuſes* B. &c. and ſecondly into *Oceans* G. &c.

A *Continent* is a large Tract of Land, including many Kingdoms, and divers Countries, not any where ſeparated by the Sea: of ſuch there are commonly reckon'd four; namely, *Europe*, *Aſia*, *Africa*, and *America*: Though, in reality, there are but two; namely, that of *Europe*, *Aſia*, and *Africa*, making one; and North and South *America*, the other.

An *Iſthmus*, is a narrow Neck of Land, joining a *Peninſula* to the Continent; ſuch is that of *Corinth*, betwixt the *Morea* and *Greece*; and of *Panama*, betwixt the Kingdoms of *Peru* and *Mexico*.

A *Peninſula*, is a Part of Land, that is almoſt ſurrounded with Water, and which is join'd to the Continent by an *Iſthmus*; ſuch is the *Morea* above mention'd: As is alſo *Africa*, with regard to *Aſia*, being join'd to the

the latter by that Neck of Land, or *Iſthmus*, which lies betwixt *Egypt* and the *Red Sea*.

An *Iſland*, is a Part of the Globe that is intirely compaſs'd about with Water: Of this kind is *Madagaſcar*, *Sicily*, *Great Britain*, and *Ireland*.

A *Mountain*, is a high riſing Ground or Eminence, which over-looks the adjacent Country. Some of them are of ſo high an Elevation, that when they are view'd at a proper diſtance, they appear like great Clouds in the Atmoſphere: Such are the *Alps*, the Pike of *Teneriffe*, Mount *Atlas*, and the *Hyperborean* Mountains.

A *Promontory*, is a Head or Cape of Land, which ſhoots itſelf into the Sea: Such is the *Cape of Good Hope* in *Africa*, *Cape Horn* in *America*; the North and South *Forelands*, *&c.*

The *Ocean*, is properly that general Collection of ſalt Water, which waſhes the ſeveral Parts of the Land and Continent; according to which it receives its Denomination. Thus, in regard to the four principal Quarters of the World, it is called, either the Eaſtern, or Oriental Ocean; the Weſtern, or Occidental Ocean; the Southern, or Meridional Ocean; and the Northern, or Septentrional Ocean. It hath alſo other Names, from being the Boundary, or waſhing the Shores of ſeveral Countries: Thus, from

from waſhing the Foot of Mount *Atlas*, it is call'd the *Atlantick* Ocean; and, more to the ſouthward, where it waſhes the ſeveral Shores of *Guinea*, along the Coaſt of *Ethiopia*, it is call'd the *Ethiopic* Ocean. Where it waſheth the Coaſt of *India*, it is call'd the *Indian* Ocean, *&c.*

The *Sea*, or more properly, a *Sea*, is only a Part of the Ocean, interrupted by divers Iſlands, and nearly environed with Land; ſuch is the *Mediterranean*, the *Baltick*, the *Euxine*, the *Caſpian*, and the *Red Sea*.

A *Lake*, is a deep Collection of Water, quite encompaſs'd with Land; and commonly retaining its own Water, without the leaſt Communication with the Sea: ſuch is that of *Sodom*, *Geneva*, &c.

A *Gulph*, is nearly the ſame Portion of the Sea as a *Peninſula* is of Land. It is every way encloſed, excepting one narrow Paſſage, whereby it communicates with the Main Ocean; ſuch are the Gulphs of *Venice*, of the *Red-Sea*, &c.

A *Strait*, called ſometimes a *Channel*, is an open, though narrow Paſſage betwixt two Shores: Of this kind are the Straits of *Gibraltar*, *Babelmandel*, *Magellan*, &c.

A *Creek*, is a narrow Part, or Arm of the Sea, running a little way (a Furlong we will ſuppoſe) into the Land. They are almoſt infinite upon every Coaſt.

A

A *Bay*, is a much larger Inlet, and more ſafe and capacious for Ships to anchor in: Such is the Bay of *Biſcay*, *Torbay*, &c.

A *River*, is a Collection of ſalt or freſh Water, perpetually iſſuing out of one or more Fountains, and joining together, till they fall into ſome conſiderable Lake, or into the Sea. The principal of which are the *Nile*, that of the *Amazons*, *Senegal*, the *Danube*, *Volga*, *Rio-de-la-Plata*, &c.

By theſe, and ſuch-like Bounds, the four principal Quarters of the World, before mention'd, are ſubdivided into various Provinces, of different Manners, Polities, and Cuſtoms. Thus

Europe is bounded, on the Eaſt, by the River *Tanais*; on the North, by the *Frozen-Sea*; on the Weſt, with the *Atlantick* Ocean; and to the South, with the *Mediterranean* Sea.

Its principal Provinces, are

Plate IX.

1. *Scandinavia*, including
   Norway, A.
   Denmark, B. and
   Sweden, C.
2. *Moſcovia* or *Ruſſia*, D.
3. *Germany*, E.
4. *Poland*, F.
5. *France*, G.
6. *Italy*, H.

7.

7. *Spain*, I. and
Portugal, K.
8. *Turkey*, L. including
Hungary, M.
Romania, N.
Greece, O.
Dalmatia, P.
Sclavonia, Q. and Part of
Tartary, R.

Its principal Iſlands, are

Plate IX.

1. *Great Britain*, including
England,
Scotland, and
Wales.
2. *Ireland*.
3. *Sardinia*.
4. *Corſica*.
5. *Sicily*.
6. *Candia*.
7. *Negropont*, and
8. *Cyprus*.

Aſia is bounded on the Eaſt, by the *Indian* Sea; on the North, by the *Tartarian* Ocean; on the South by the *Arabian* Gulph; and on the Weſt by the River *Tanais*.

Its chief Provinces, are

1. *Turkey*, including
Natolia, S.
Arabia, T.
Syria, V.

Paleſtine,

Paleſtine, W.
Georgia, X.
Chaldæa, or *Diarbeck*, Y.
Meſopotamia, Z. and
Turcomania, &.

2. *Perſia*; including
Aſſyria, a.
Parthia, b. and
Media, c.
3. *India*, d.
4. *China*, e. and
5. *Great Tartary*, f.

The principal Iſlands, are

1. *Japan.*
2. *Sumatra.*
3. *Borneo.*
4. *Metellino.*
5. *Rhodes.*
6. *Scio.* and
7. *Samos.*

Africa is bounded on the South, by the *Antarctic* Sea; on the North, by the *Mediterranean*; on the Eaſt, by the *Arabian* Gulph, and *Indian* Ocean; and on the Weſt, by the *Atlantic.*

Its chief Provinces, are

1. *Egypt*, g.
2. The *Sahara*, or Deſart, h.
3. *Nubia*, i.
4. *Barbary*, k.

5.

5. *Guinea*, l.
6. *Negro-Land*, m.
7. *Bilidulgerid*, n.
8. *Ethiopia*, including
Monomotapa, o. and *Abyſſinia*, p.

Its principal Iſlands, are

1. Thoſe of Cape *Verde*.
2. The *Canarys*.
3. The *Azores*.
4. *Maltha* over againſt *Sicily*.
5. *Madera*, and
6. *Madagaſcar*.

America, is bounded on the Weſt, by the Great South-Sea; on the Eaſt, by the *Atlantic*; on the South, by the Sea of *Magellan*; and on the North, by the *Hyperborean* Ocean.

It is divided into two Parts, *viz.*

Mexicana, and *Peruana*.

Whereof the latter hath theſe Provinces, *viz.*

Terra Magellanica, A.
Brazilla, B.
Chili, C.
Country of the *Amazon's*, D.
Guiana, E.
Peru, F.
Panama, G.

Car-

Carthagena, H. and
Paraguay, I.

The chief Iſlands, are

1. *Hiſpaniola.*
2. *Cuba.*
3. *Jamaica.*
4. *Port Rico*, and
5. *Barbados.*

Mexicana has theſe Provinces, *viz.*

Mexico, or *New Spain*, K.
Maryland, L.
New England, M.
Florida, N.
Penſilvania, O.
New France, P.
Carolina, Q.
New Jerſey, R.
Greenland, S.
Virginia, T. and
New York, V.

The principal Iſlands, are

1. *Newfoundland.*
2. *Bermundas*, and
3. *Iceland.*

The Ancients have divided the Terreſtrial Globe into five Parts, call'd *Zones*; of which, and their Inhabitants, as follows.

CHAP. VI.

Of the ZONES.

BESIDES the foregoing Diviſion of the Globe, into Continents, Countries, and Provinces; the Tropics and Polar Circles divide it likewiſe into five diſtinct Parts, call'd *Zones*, *(viz.)* two *Temperate*, one *Torrid*, and two *Frigid*. The Inhabitants of which, according to the various Direction of their Meridional Shadows, receive different Names.

See the adjacent Scheme, Plate X. Fig. 1.

Of theſe *Zones*, that, which is call'd the *Torrid*, and lies betwixt the two Tropics, where the Sun-Beams are perpendicular, almoſt at all times of the Year, was thought, tho' without Reaſon, by the Ancients, to be ſo far intemperate, as not to be inhabited.

The Inhabitants of it are call'd AMPHISCII: Which having the Sun, at different times of the Year, both to the Northward and Southward of their *Zenith*, caſt their Shadow at Noon both ways, *i. e.* when the Sun is in the Southern Signs, their Meridian Shadows point to the North; and when in the Northern Signs, their Shadows fall to the South: But when, at the changing of the

theſe Directions (which is twice every Year) the Sun becomes Vertical to them, and they have no Shadow at all; then they are call'd ASCII, *i.e.* without Shadows.

The Temperate *Zones* lie betwixt the Tropics and Polar Circles, where the Sun's Beams fall more obliquely, in a Degree betwixt the Extreams of Heat and Cold.

The Inhabitants of theſe are call'd HETEROSCII. To them, the Sun appears either to the North or South all the Year long, according as they themſelves are ſituated from the Equator; conſequently each particular Noonday Shadow is thrown contrary, one northward, the other ſouthward; and, on either Side, the Celeſtial Motions appear oblique.

The two Frigid *Zones* lie betwixt their reſpective Polar Circles and the Poles, and were ſuppoſed by the Antients to be uninhabited.

The Inhabitants are call'd PERISCII. In both theſe *Zones*, the Sun being vaſtly oblique, very faintly diſperſes Light and Heat; and at one particular Time of the Year, for ſeveral Days together, according as they are diſtant from the Pole, their Shadows go round about them.

The Inhabitants of the Earth, with regard to their reſpective Poſitions to each other, are alſo repreſented under three different Situations.

Plate X. Fig. 2.

Thoſe who live diametrically oppoſite to each other (as A B) are call'd ANTIPODES; having all Things, with regard to the Sphere, directly contrary one to another: Such as the Time of the Day, the Seaſons of the Year, *&c.* They are 180 Degrees different in Longitude, and have the ſame Degree of Latitude, but of different Denominations; *i. e.* they are both in the ſame Meridian, but one of them is North, and the other South. Therefore, when it is Spring with the one, 'tis Autumn with the other; and if it is Noon with the one, 'tis Midnight with the other.

Thoſe who live in two oppoſite Points of the ſame Parallel (as A D) are call'd PERIÆCI. They have the ſame diurnal Arch, but differ juſt half a Day in the Account of Time; ſo that when the Sun is in the Equinoxes, and riſes to one, it ſets to the other.

Thoſe who live in the ſame diurnal Meridian, and under two different Parallels, equally diſtant from the Equator (as E F) are call'd ANTÆCI. They have nothing common but their Noon-Tides; their diurnal Arches are a Supplement to each other, and their Seaſons oppoſite; Conſequently when it is Winter with the one, 'tis Summer with the other; and if the Arch is 15 Hours in the one, it will be 9 in the other.

CHAP.

CHAP. VII.

Of the Climates, *&c.*

THE Surface of the Earth, by a certain Number of imaginary Circles, (running parallel to each other) is divided into various Tracts, call'd *Climates.* They are ſuppoſed to be drawn at ſuch a Diſtance, that the longeſt in each (ſucceſſively increaſing) exceeds that of the former, by half an hour: Of theſe ſort of Parallels there are 48; or, more properly, 24 on each ſide of the Equator. To which, if we add 6 more, (of a different Nature, ariſing from the Increaſe of one intire Month,) lying betwixt the Polar Circles and the Poles, it will make in all, 60, *i. e.* 30 North, and 30 South.

Theſe were by the Ancients accounted 96; and by them call'd *Parallels of the longeſt Day.* The Space, limited betwixt any two of them, was equal to 15 Minutes of Time; ſo that their Increaſe of Artificial Days was diſtinguiſh'd formerly, by what is now but half a Climate.

Before the North Part of the World was diſcover'd, or the Middle Part was fully de-

ſcribed, there were no more than 9 Climates; as may be ſeen in the ſecond Column of the following Table.

A TABLE *of the* CLIMATES, *determining the Length of the longeſt Day, in any Latitude, between the Equator and the Polar Circles.*

Climates.					
Antient.			Modern.		
			N°	Latitude	Longeſt Day.
				D. M.	H. M.
	Æ	*Amphiſcii*, per		O.	XII
1		Taprobanam.		4 : 15	12 : 15
2		Sinum Aualitum.	1	8 : 25	12 : 30
3		Sinum Aduliticum.		12 : 30	12 : 45
4		Meroen.	2	16 : 27	XIII.
5	I	Napata.		20 : 15	13 : 15
6		Syenem.	3	23 : 51	13 : 30
		Heteroſcii, per			
7	II	Ptolemaida.		27 : 41	13 : 45
8		Alexandriam.	4	30 : 21	XIV.
9	III	Phœnicem.		33 : 19	14 : 15
10		Rhodum.	5	36 : 24	14 : 30
11	IV	Smirnem.		38 : 32	14 : 45
12		Helleſpontem.	6	40 : 56	XV
13	V	Maſſiliam.		43 : 5	15 : 15
14		Pontum.	7	45 : 1	15 : 30
15	VI	Danubii Fontes.		46 : 51	15 : 45
16		Boriſthenis, Fluv. Oſtia.	8	48 : 32	XVI
17	VII	Mæotida Paludem.		50 : 00	16 : 15
18		Brabantiam.	9	51 : 30	16 : 30
19	VIII	Angliæ Medium.		52 : 50	16 : 45

The TABLE continu'd.

20		Tanais, Flu. Oitia.	10	54 : 3	XVII
21	IX	Bullæum Angliæ.		55 : 2	17 : 15
22		Britanniam Mediam.	11	56 : 1	17 : 30
23		Camulodunum Angl.		57 : 0	17 : 45
24		Hiberniam.	12	58 : 0	XVIII
26		Medium Hiberniæ.	13	59 : 38	18 : 30
28		Orchades insu. Scotiæ.	14	61 : 12	XIX
30		Ebudas Insulas.	15	62 : 18	19 : 30
36		Thylem Insulam.	16	63 : 14	XX
39		Scythiam.	18	64 : 40	XXI
40		——— Idem.	20	65 : 34	XXII
44		Gotthiam.	22	66 : 16	XXIII
48		——— Idem.	24	66 : 30	XXIV

Of the Periscii, *or* Climates *betwixt the Polar Circles and the Poles.*

Climates.					
Antient.			Modern.		
			N°	Latitude	Length of Day.
				D. M.	Months
Frigid Zones.	I	Gotthiam.	25	67 : 32	1.
	II	Islandiam.	26	69 : 40	2.
	III	Pilappos.	27	73 : 29	3.
	IV	Mare Glaciale.	28	78 : 24	4.
	V	——— Idem.	29	84 : 2	5.
	VI	Polus Mundi.	30	90	6.

CHAP. VIII.

Of ſuch Aſtronomical and Geographical Definitions, *as are neceſſary to be known before we explain the* Uſe of the GLOBES.

THE Sphere, with regard to the various Poſitions of it, is either

Parallel,
Direct, or
Oblique.

Plate XI. A *Parallel Sphere*, is that Poſition of the Globe, where the viſible Pole becomes the Vertical Point; and conſequently, is directly under the North and South Poles of the Heavens. Here the Meridians are *Azimuth Circles*, and the Parallels *Almicanthers*. Such it is repreſented by Fig. 1.

The Inhabitants, if any ſuch there be, have theſe ſurprizing *Phænomena:* They have ſix Months Day, and ſix Months Night; the Sun and Moon are always in the Meridian; The Stars never riſe, or ſet; but all of them deſcribe true *Almicanthers*, and conſtantly appear on one Point of the Compaſs. The Poles

Problems of this kind are the Subject of near $\frac{1}{3}$ of Mr. *Gordon*'s Paradoxes.

Poles are in the Zenith and Nadir, and the Equator is their Rational Horizon.

A *Direct*, or *Right Sphere*, is that Poſition of the Globe where the Equinoctial becomes the prime Vertic Circle, and the Poles the two oppoſite Points in the Horizon. The * Inhabitants are thoſe who live in the Equator; to whom the Sun riſes, and falls nearly perpendicular. See Fig. 3. Fig. 3.

An *Oblique Sphere*, is the Caſe of all other Parts of the Globe, (excepting the forementionʼd, *i. e.* under the Poles, and in the Equator.) In this Poſition the viſible Part of every Parallel of Latitude, or Declination, becomes a Diurnal Arch; and that which is depreſsʼd below the Horizon, is callʼd the *Nocturnal one*. Fig. 2.

Of the HORIZON.

The *Horizon*, is that Circle which bounds the Sight, and divides the upper or viſible Hemiſphere, from the inviſible, or that below it.

Every Station of the Earthʼs Surface has two *Horizons*; one of which is callʼd the *Senſible*, the other the *Rational*. They are exactly parallel to each other, but near 4000 Miles aſunder.

The *Rational Horizon*, is a Circle which is ſuppoſʼd to divide the Earth into two equal

* In this Part of the Globe, the Sun is ſaid by ſome Writers, though upon a falſe Theory, to have no Amplitude.

equal Parts, every way 90° from the Obſerver's Station. It is call'd the *True Horizon*, becauſe to one at the Center of the Earth, it would appear an univerſal Plain, void of Parallax. It is repreſented by the wooden Frame of either Globe.

The *Senſible Horizon*, is that apparent Circle, where the Surface of the Globe and the Sky ſeems to meet; which determines the riſing and ſetting of the Sun, and other heavenly Bodies. It is very rugged, and irregular, occaſion'd by the Unevenneſs of the Ground; but on the Sea, where the Mountains are out of ſight, it forms a compleat Circle; the Radius of which, (if view'd from the Deck of a Ship) is generally about five or ſix Leagues.

N. B. The Difference ariſing from theſe two Horizons, when compar'd with the immenſe Diſtance of the heavenly Bodies, is ſo very ſmall, that, in the Motion of all the primary Planets, and fix'd Stars, moſt Aſtronomers have thought fit to omit it, as inconſiderable; but with regard to the Moon, it is more diſtinguiſhable, and requires the whole Doctrine of Parallaxes to ſhew its various Effects.

By

By *Parallax*, is meant a Change of Place of any *Phænomenon*, and is of two kinds, *diurnal* and *annual*. The *diurnal Parallax* of any *Phænomenon* is the difference between its true Place, ſeen from the Center of the Earth, and its apparent Place, ſeen from the Earth's Surface. If the *Phænomenon* be in the Horizon of the Place from whence it is view'd, this *Parallax* is then greateſt, and is call'd its *horizontal Parallax*. The *annual Parallax* of a *Phænomenon* is the difference of its *Heliocentric* Place, ſeen from the Sun, and its *Geocentric* Place, ſeen from the Earth. This is alſo call'd the *Parallax* of the Earth's Orbit.

Beſides this of the *Parallax*, there is another Diverſity of Appearance, call'd *Refraction*; proceeding from the Vapours ariſing from the Earth, and the thick Denſity of the Air ſurrounding it; through which Medium the viſual Ray of any Luminous Body comes to the Eye not in a right Line, but in a Curve. Hence it is, that the Planets, and other Objects, appear to us before they riſe, and ſeem to ſet later than they really do.

CHAP.

CHAP. IX.

The Geographical *and* Aſtronomical TERMS *continued.*

THE *Latitude* of a Place, is the Height of the Pole above the Horizon; being always equal, upon Earth, to the Diſtance betwixt the Place given and the Equator; and, upon the Heavens, between the Equinoctial and Zenith.

The *Latitude* of any Star, or Planet, is its neareſt Diſtance in Degrees from the Ecliptic; and is either North or South, in a direct Line or great Circle, paſſing through the Ecliptic Poles.

The *Longitude* of a Star, *&c.* is an Arch of the Ecliptic, cut by a great Circle paſſing through the Poles of the Ecliptic, and thro' the Center of the ſaid Star: it is generally counted from the Equinoctial Point *Aries*, and from thence towards *Cancer*; and ſo on thro' *Libra* and *Capricorn*, according to the Succeſſion of Signs.

*Longitude**, upon Earth, is the Diſtance of any Place, either to the Eaſt or Weſt, from

* The greateſt Diſtance of any two Places, counted in this manner, is under the Equator: the Diſtance ſtill decreaſing, North or South, to the Pole, ends in nothing; as may be ſeen in the Table.

from the firſt * Meridian. It is much the ſame with the *Right Aſcenſion* of Stars, *&c.* in the Heavens; being properly that Part of the Equinoctial counted from the beginning of *Aries*, which riſes or ſets with the Sun, or any of the Stars, in a right Sphere; but in an oblique one, it is the Degree, and Minute of the ſame, cut by the Meridian.

Declination, in the Heaven, is the ſame as *Latitude* upon the Earth, being the true Diſtance of any Planet, *&c.* from the Equinoctial, North or South; and is reckon'd upon the univerſal Meridian.

Aſcenſion, is the riſing, or elevation of any Object above the *Horizon.* As

Deſcenſion is the ſetting of the ſame.

Altitude, is the Height of the Sun, or of any other *Phænomenon* above the Horizon, and is comprehended in an *Azimuth* Circle, betwixt the Horizon and the Zenith Point.

Oblique Aſcenſion, or *Deſcenſion*, is that Portion of the *Equinoctial*, cut by the Horizon, thro' the Center of any known Star, at its true Riſing, or Setting; and is counted from the Beginning of *Aries.*

Aſcenſional Difference, is the Number of Degrees included betwixt the right, and the oblique Aſcenſion.

Amplitude,

* The *Engliſh* fix their firſt Meridian at *London*; the *French*, at *Paris*; others at the Iſland of *Fero*, &c.

Amplitude, is an Arch of the Horizon, intercepted between the Center of any Planet, and the two prime Vertical Points of the Horizon. It is either North or South, as the Sun, the Planets or Stars have North or South Declination.

CHAP

CHAP. X.

Of the Uſe of the GLOBES, *and of ſuch* Propoſitions *as may be ſolved by either of them.*

PROB. I.

THE Day of the Month being given, to find the Sun's Place in the Ecliptic.

The RULE.

Look, on the upper Side of the *Horizon* or wooden Frame, for the given Day of the Month, either in the *Julian* or *Gregorian* Calendar, and over againſt it, in the Circle of Signs, is the Degree requir'd, wherein the Sun will be that Day at Noon.

Thus for EXAMPLE.

Let it be requir'd to find the Sun's Place, on the 5th of May, O. S. *(or according to the* Julian *Account) at Noon.*

Now the Day being found, over againſt it is 25° of *Taurus*.

In like Manner.

His Place for the	6 of *March*	will be found	27° ♓
	12 of *May*		3° ♊
	9 of *July*		27° ♋

And

And his Ingreſs into the ſeveral Signs, nearly as follow, *viz.* into the

Spring Signs, *viz.*
Aries, *March* 9th.
Taurus, *April* 9th.
Gemini, *May* 10th.

Summer Signs, *viz.*
Cancer, *June* 10th.
Leo, *July* 12th.
Virgo, *Auguſt* 12th.

Autumnal Signs, *viz.*
Libra, *September* 12th.
Scorpio, *October* 12th.
Sagittarius, *November* 11th.

Winter Signs, *viz.*
Capricornus, *December* 10th.
Aquarius, *January* 9th.
Piſces, *February* 7th or 8th.

PROB. II.

The Sun's Place being known, to find his Right Aſcenſion, *and* Declination.

The RULE.

1. For the *Right Aſcenſion*;

Bring the Sun's Place in the Ecliptic, to the Brazen Meridian, and under its graduated Edge, in the Equinoctial, you will find the Degree requir'd.

2. For the *Declination*;

The Globe being kept in the former Poſition, the Degrees in the Meridian intercepted

cepted betwixt the Sun's Place and the Equator, will be the *Declination.*

As for EXAMPLE.

I would know the Sun's Right Aſcenſion, and Declination, on the 5th of May, *being then in* 25° of ♉.

By the foregoing Rule, you'll find in the Meridian 19°; which being North of the Equator, or Equinoctial, is call'd his North Declination, and in the Equinoctial, will be found 52° ½ his Right Aſcenſion; which if requir'd in Time, is done from the Table, at the End of the Book.

N. B. During the Sun's Progreſs through ♈, ♉, ♊, ♋, ♌, and ♍, his Declination is North, and his Right Aſcenſion leſs than 180°: but when the Sun is in ♎, ♏, ♐, ♑, ♒, and ♓, his Declination is call'd South, and his Right Aſcenſion more than 180°, but never exceeds 360°.

For the more eaſy underſtanding of the foregoing Propoſitions, obſerve the Figures in Plate VII. Fig. 1. 2. where A B repreſents the Sun's Place, C his Right Aſcenſion, and D his Declination.

PROB. III.

To rectify the Globe, and the Hour-Index, at any time, for any given Latitude.

The RULE.

Turn the Globe and wooden Frame, till the graduated Side of the Meridian be directly towards you; then move the Meridian up, or down, in the wooden Frame, till the given Latitude, in Degrees and Minutes, coincides with the *Horizon*; in which Situation it will repreſent the true Poſition of the Heavens, or of the Earth, for the Place deſign'd.

For the Hour-Index, or Time;

Firſt find the Sun's Place, and bring it to the Meridian; then, the Globe being kept ſteady, put the Index to 12 o' clock at Noon; when that is done, the Globe is rectified, and fit for Uſe.

Thus for EXAMPLE.

In Plate VIII. Fig. 2. it is rectified for *London*; where, as in all other Places of the northern Hemiſphere, the North Pole muſt always correſpond with the northern Part of the Horizon, *&c.*

PROB. IV.

To find, at what time the Sun riſes, or ſets; and conſequently what is the Length of Day, or Night.

The RULE.

The Globe being rectified as above, bring the Sun's Place to the Horizon, on the eaſt

eaſt Side of the Globe; then ſee what Hour the Index points to, which is the true time of the Sun's Riſing: or, if requir'd, turn the Globe till the Sun's Place come to the weſt Part of the Horizon, and then the Index will ſhew the Hour, and Minute, of the Sun's Setting. Or ſubſtract the Time or Hour of the Sun's Riſing, from 12 o' clock, and then doubling the Sum, you will have the Length of the Day, which being ſubſtracted from 24 Hours, will be the Length of the Night.

As for EXAMPLE.

Let it be required to know at what Time the Sun will riſe, &c. *to us at* London, *on the 5th of* May.

The Sun's Place for that Day is 25° of ♉; which being brought, to the Horizon, Eaſtward, the Index will point to 4 Hours, 15 Minutes for the Riſing; which being ſubſtracted from 12 Hours, (or the ſame Degree being brought to the weſtern Horizon) will ſhew the Setting, at nearly 7 Hours, 45 Minutes. Let this be doubled, and the Length of the Day will be 15 Hours, 30 Minutes; and if it be ſubſtracted from 24 Hours, it will give 8 Hours, 30′, for the Length of the Night, of the Day requir'd. Thus in Pl. VIII. Fig. 3. A repreſents the Sun, and B the Index and Hour-Circle. After the ſame manner, on the 14th Day of *February*,

		H.	M.
The Time of ⊙ Rising	will be	6	48
The Time of ⊙ Setting	will be	5	12
The diurnal Arch	will be	10	24
The nocturnal Arch	will be	13	36

PROB. V.

To find at any Time of the Year, the Beginning, and End of the Crepuſculum, *or* Twilight *.

Now the RULE to find this, is to rectify the Globe as above, for the Time required; and after having fixed the Quadrant of Altitude to the Zenith, turn the Globe about till the Earth's Place on the Ecliptic, (which is always oppoſite to that of the Sun) interſect 18° of the Quadrant of Altitude; and then, according as the ſaid Quadrant is brought to the weſtern or eaſtern Side of the Meridian, the Index of the Hour Circle will give the Beginning and End of the Morning or Evening *Twilight*: which being ſubſtracted from the Time of Sun Riſing, or Setting, gives the Length or Duration of the *Twilight*.

Thus

* The Duration of *Twilight* is that Space of Time which is included betwixt Day-Break and Sun-Riſe, and betwixt Sun-Set and dark Night. The Sun, at the Beginning of the former, and the End of the latter, being depreſſed 18° below the Horizon.

Thus for EXAMPLE.

On the 20th of *Auguſt*, Lat. 51, 30, the Sun being then in 8° of *Virgo*, its oppoſite Sign will be 8° of *Piſces*; and conſequently when 8° of *Virgo* is depreſs'd 18° below the Horizon, 8° of *Piſces* will be the ſame number of Degrees above it. And in this Poſition, the Quadrant of Altitude being brought to the weſt Side of the Meridian, and interſecting 8° of *Piſces*, will give upon the Hour-Circle, three o' clock in the Morning for the Beginning of *Twilight*; and being turned to the eaſt Side, will give nine o' clock for the End of *Twilight* in the Evening; which being ſubſtracted from the Sun Riſing, *&c.* will give 2 Hours and 15′ for the Length of *Twilight*.

PROB. VI.

To find the Sun's Meridian Altitude, or his Altitude at any Time of the Day; and at the ſame Time to find his Azimuth.

The RULE.

The Globe being rectified, bring the Sun's Place to the Meridian, and there fix it; then count how many Degrees are contain'd betwixt the Sun's Place and the Horizon, and that will be the Altitude required.

Or thus,

Fix the Quadrant of Altitude to the Zenith, and turn its graduated Edge to the

Sun in the Meridian; then counting the Degrees from the Horizon, you will have the ſame. Or having found his Declination, if North, add it; but if South, ſubſtract it from the Height of the Equinoctial, or the Diſtance of the Pole from the Zenith *, and the Sum or Difference will give you the ſame.

As for EXAMPLE.

Let the Sun's Meridian Altitude be requir'd at London, *for the* 10*th of* May.

The Sun's Declination for that Day is 22° North; the Height of the *Equinox* is 38°, 30′; their Sum then, *viz.* 60°, 30′, is the Altitude requir'd.

2. *Let his Altitude and Azimuth be required at any other Time.*

Every Thing being rectified as before, with the Quadrant of Altitude at the *Zenith*, turn the Globe about, upon its Axis, till the Index points to the given Hour, and there fix it; then move the Quadrant of Altitude, till the graduated Edge of it interſect the Sun's Place, and there will be ſhewn his Altitude.

Laſtly, take notice what Degree is cut by the ſame Edge of the Quadrant, in the Horizon,

* This is always equal to the Difference between the Latitude of the Place and 90°, and call'd *the Compliment of Latitude.*

rizon, counting either from North or South, and that will be the *Azimuth* required.

Thus for EXAMPLE.

On the 17th Day of *June*, at ſix o' clock in the Morning, the Sun's Altitude will be 19°, 50′, and his Azimuth 104°, 30′ from the South, eaſtward. Alſo *May* the 20th, at two in the Afternoon the Sun's Altitude will be 52 Degrees, and his Azimuth about 50, from the South, weſtward.

Thus in Pl. XI. Fig. 4. A repreſents the Time, B the Sun's Place, C his Altitude, and D his Azimuth.

PROB. VII.

To find the Sun's Amplitude, his oblique Aſcenſion, or oblique Deſcenſion.

The RULE.

The Globe being rectified as before, bring the Sun's Place to the Horizon, eaſtward; then the Globe being kept ſteady, obſerve what Degree and Minute of the Equator then riſeth to the Eaſt, and that will be the oblique Aſcenſion.

Again, the Globe being turn'd to the Weſt, look what Degree of the Equinoctial will ſet with the Sun, and that is the oblique Deſcenſion.

Laſtly, over againſt the Sun's Place, in the Horizon, either at Riſing or Setting,

will be the Degree of Amplitude, North or South, according to the Declination.

Thus, the Sun (in the Lat. of *London*) being in the Beginning of *Taurus*, the oblique Aſcenſion will be 13°, 45′, the oblique Deſcenſion 41°, 25′, the Amplitude 18°, 30′. Or, as it is expreſs'd in Plate XI. Fig. 5. where A is the oblique Aſcenſion, and B the Amplitude.

PROB. VIII.

To find the Latitude of the Place, and the Hour of the Day.

The RULE.

Firſt, fix a Pin perpendicular to the Sun's Place, then obſerve by a Compaſs, or any known Mark, the Sun's Place in the Meridian; then again fix the Globe in its true Poſition, North and South, and elevate or depreſs the Axis, till the Pin at the Meridian caſts no Shadow; that Point will be the true Center of the illuminated Hemiſphere. In this manner the Globe will be naturally rectified, and the Latitude will be ſhewn on the Brazen Meridian, cut by the Horizon at the North.

Then for the Hour of the Day *.

The Globe remaining in that Poſture, rectify

* For working this laſt Propoſition, the Globe muſt be fix'd ſo, as to receive the Light of the Sun during the whole time of ſhining.

rectify the Hour-Index, and the Pin, if required, to any other time; then turn the Globe round to the Sun, and when you find the Pin has no Shadow, the Index at the Pole will give the Hour.

CHAP.

CHAP. XI.

Propoſitions more immediately ſolved by the Celeſtial GLOBE.

PROB. I.

To find the Right Aſcenſion and Declination of any Star.

The RULE.

THE given Star being found, bring the Center of it to the South Part of the Meridian, (as in Prob. II. of the laſt Chap. you did the Sun) then right above it, you'll find the Declination, and, in the Equinoctial, the Right Aſcenſion: the former in the Meridian, the latter cut by it. Thus

The	Right Aſcenſion	of * *Lyra*	will be	276 : 54	
	Declination			38 : 33	N.
	Right Aſcenſion	of † *Rigel*		75 : 21	
	Declination			8 : 33	S.
	Right Aſcenſion	of ‡ *Syrius*		98 : 16	
	Declination			16 : 21	

PROB. II.

To find the Latitude and Longitude of any Star, and the Place of any Planet, if marked on the Globe.

The

* A bright Star in the Harp of *Apollo*. † The Left Foot of *Orion*. ‡ In the Great Dog's Mouth.

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THE CELESTIAL GLOBE

The RULE.

First, bring the ſolſtitial Colure to the Brazen Meridian, *i. e.* to lie directly under it; then elevate, or depreſs the Pole of that Hemiſphere, in which the Star is found, till the Poles of the Ecliptic be exactly in the Zenith and Nadir, *i. e.* till the Ecliptic concide with the Horizon; keeping the Globe in this Poſition, rectify the Quadrant of Altitude, and move it till its graduated Edge paſs or lie juſt over the Center of the given Star, and there fix it. Then ſee what Degree lies over-againſt the Star's Center on the Quadrant, and what Portion of the Ecliptic, now lying in the Horizon, is cut by the Quadrant, and the former will be the Latitude of the ſaid Star, and the latter its Longitude from *Aries*.

Thus for EXAMPLE.

Let the Latitude and Longitude of Procyon, *a bright Star in the Little Dog, be required.*

The Globe and the Quadrant of Altitude being in the Poſition above, the Latitude will be 16°, 5′ South, and the Longitude in ♋ 22°, 1′.

By the ſame RULE

The { Latitude / Longitude } of * *Aldebaran* / { Latitude / Longitude } of ‡ *Algol* } will be { 5 : 31 S. / 5 : 54 ♊ / 22 : 20 N. / 22 : 20 ♉ }

* *Oculus Tauri*, or the Bull's Eye. ‡ In the Head of *Meduſa*.

Or

Or as in Plate XII. Fig. 4. A is the given Star *Algol*, B the Latitude of it, and C the Longitude from ♈.

PROB. III.

To find the Riſing and Setting of any Star, &c.

The RULE.

The Globe being rectified, bring the Star, whoſe Riſing is requir'd, to the eaſt Part of the Horizon; then the Index at the Pole will ſhew the Hour and Minute of its Riſing; and in like manner, if the Globe is turn'd to the Weſt, it will ſhew the Setting *.

For EXAMPLE.

Let it be requir'd to find the Riſing and Setting of the Pleiades, *a bright Knot of ſmall Stars in the* Bull.

The Globe being rectified to the Latitude, we will ſuppoſe of *London*, and the Hour-Index to the Sun's Place for the given Day, *viz.* the 12th Day of *December*, the Sun being then near the Tropic of *Capricorn*; bring the given Stars to the Plain of the Horizon, and the Hour-Index will give 1 H. 14 M. in

* *N. B.* The Riſing and Setting of any Star being found, in Hours and Minutes, the one ſubſtracted from the other, *i. e.* the firſt from the laſt, gives the Nocturnal Arch, or the Time of its Stay above the Horizon: but if the Setting be leſs than the Riſing, add thereto 12 Hours, and from the whole deduct the Riſing, and there will remain the Sum requir'd.

in the Afternoon for the Time of their Riſing, and 5 H. 38 M. in the Morning for the Time of Setting.

N. B. In the ſame Manner the Riſing and Setting of any Planet may be found, regard being had to its Place in the Ecliptic, which may be known at any time, by an *Ephemeris*.

PROB. IV.

To know at any time what Stars are Aſcending or Deſcending.

Move the Globe about (all things being rectified as above) to the given Hour, and there fix it; and then obſerving what Stars lie even with the Horizon, thoſe on the Eaſt Side are ſaid to be Riſing, and thoſe to the Weſt Setting. Thoſe under the Meridian, are ſaid to be *Culminating*, being then full South; as thoſe on the Eaſt Side of the Globe are Aſcending, and thoſe on the Weſt Deſcending: What are below the Horizon, being inviſible. Laſtly, if you place the Quadrant of Altitude, over the Center of any particular Star, it will ſhew you its Altitude, and at the ſame time gives, upon the Horizon, the Azimuth requir'd.

Thus as in Plate XII. Fig. 5. on or near the Winter Solſtice, about 9 o'clock at Night the Conſtellation *Orion*, will be found in the South-Eaſt, betwixt 20 and 30 Degrees high;

high; the Dog Star at S. E. ½ E. his Altitude nearly 5°, and the Lion's Heart, *Regulus* or *Baſilica* juſt riſing.

PROB. V.

How to diſtinguiſh one Star from another in the Heavens, and know them by their Names on the Globe.

The RULE.

The Meridian being placed due North and South, and the Globe rectified to the Time and Latitude required, each Part of the Globe will correſpond with its reſpective Conſtellation in the Heavens; ſo that if the Globe was tranſparent, and the Obſerver's Eye placed in the Center, every artificial Star, painted upon it, would appear concentric with the real one.

PROB. VI.

To find their Amplitude, and their oblique Aſcenſion, or Deſcenſion.

Obſerve what Degree of the Equator riſes or ſets with each, or any one of them, and that is the Thing requir'd: or if the Amplitude be deſired, ſee upon what Point of the Compaſs they firſt appear, and then that Diſtance from the Eaſt or Weſt Point of the Horizon, reduced into Degrees, will give the Quantity of the Amplitude requir'd.

PROB.

PROB. VII.

To find the Hour of the Night.

The Globe being rectified, bring the given Star to the Quadrant of Altitude, and ſee that the known Elevation (which in this caſe muſt always be taken by Obſervation, with an Inſtrument) be cut thereby, then will the Hour-Index point to the Time required: or if any known Star be in the Meridian, the Hour will be ſhewn, without knowing the Altitude, by the Index only.

In like manner may be found the Hour of the Day, by the Sun, his Altitude being given.

Thus, at London, *on the* 10*th of* May *in the Morning, the Sun's Altitude being found to be* 43°, *what is the Hour?*

It will be found to be juſt 9 o'clock, as appears by Pl. XIII. Fig. 4. where A repreſents the Sun, B C his Altitude, and D the Time requir'd.

PROB. VIII.

To know what Stars are viſible in any Latitude, and in what Latitude any particular Star firſt appears.

Rectify the Globe, according to the Latitude of the Place requir'd, and then turning it round, you will, according to the Seaſon

Seaſon of the Year, find what Conſtellations will be viſible at that Time.

If, again, you bring any particular Star to the Meridian, and move the Globe ſo as to bring the ſaid Star to the Horizon, you will find, by allowing for the Denſity of the Atmoſphere in proportion to their ſeveral Magnitudes, in what Latitude it will firſt become viſible. Thus,

Allowing for a Star of the { 1, 2, 3, 4, 5, 6 } Magnitude { 9, 10, 11, 12, 13, 14, 15 } Degrees of Elevation.

In North Latitude, where the North Pole is elevated.

You will find that { *Ariſta* ——— / The new Star in the Whale's Breaſt *o* -- / The Star in the Bow of ♐, ε ——— / The Raven's Bill, α — } will be ſeen in the Latitude of { 71, 76, 45, 55 } Degrees North.

N. B. All thoſe Stars, whoſe Diſtance from the elevated Pole is leſs than the Latitude of the Place, never ſet to their reſpective Inhabitants; as their oppoſite ones, being equally depreſſed, never riſe.

PROB.

PROB. IX.

To find the Latitude of a Place.

Having obſerved by the Eye or Teleſcope two Stars, one in the Meridian, the other at the Horizon, find the ſame upon the Globe; then ſliding the Meridian up or down, till they correſpond with their obſerv'd Poſition in the Heavens, the Globe will ſhew the Latitude requir'd. Which may likewiſe be found by obſerving the Meridian Altitude of the Sun, or any known Star, and then adding or ſubſtracting the Declination, according to the Time of the Year, *&c.* Thus in the North Hemiſphere, where the Sun's Meridian Altitude is 60°, 8′, and his Declination 20°, 11′, the Latitude will be 50° North.

PROB. X.

To find a Meridian Line.

LEMMA.

Any Star that paſſes the Meridian between the Zenith and the Pole, becomes twice Stationary, as to its Azimuth, in every diurnal Revolution, *i. e.* it does not ſenſibly change its Azimuth for ſome time, when near its greateſt Eaſt and Weſt Deviations.

Therefore, if by the help of two Plumb Lines, placed at proper Diſtances from each other, and from the Place of Obſervation you obſerve when any ſuch Star does not

change its Azimuth, but ſeems to aſcend or deſcend directly to or from the Zenith, and that both when the Star is Eaſtward or Weſtward *, you will have two Lines forming an Angle in the Place of Obſervation. Biſect this Angle, and the biſecting Line ſhall be a true Meridian.

Of Poetical Aſtronomy.

THE poetical Riſing and Setting of the Stars was much taken notice of by the antient Poets, Hiſtorians, and Huſbandmen. In thoſe Times, and in thoſe Parts of the World where the annual Inequality of the Earth's Motion is leaſt perceptible, it was the only Method whereby they could diſtinguiſh the Changes and Diverſity of the Seaſons.

Now of theſe Riſings and Settings there are three Kinds, *viz.*

The *Coſmical*,
Acronical, and
Heliacal.

The *Coſmical* Riſing of a Star, is when it riſes with the Sun; but the *Coſmical Setting*, is when it ſets as the Sun riſes.

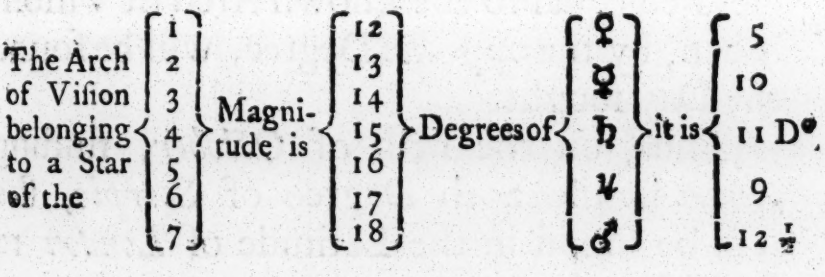
The *Acronical Riſing* of a Star, is when it riſes juſt as the Sun ſets; and the *Acronical*,

* As the fix'd Stars do not ſenſibly change their Declinations, it is not material whether both Obſervations be made the ſame day.

nical Setting of it, is when it ſets with the Sun.

The *Heliacal Riſing* of a Star is its Emerſion out of the Sun's Beams; *i. e.* when it begins to appear before Sun-Riſe, which before it cou'd not, by reaſon of its Nearneſs to the Sun.

The *Heliacal Setting* of a Star is its Immerſion, *i. e.* when it approaches ſo near the Sun, that, entering into its Arch of Viſion, it is hid in his Beams. Now what is call'd the Arch of Viſion, is comprehended betwixt the Horizon and the Center of the Sun, before he riſes, or after he is ſet; being greater or leſs, according to the ſeveral Magnitudes of the Stars and Planets. It is obſerved nearly as follows, *viz.*



PROB. XI.

To find the Time of the Year when any known Star, or Planet, will riſe or ſet Heliacal.

For the Riſing.

Rectify the Globe, and bring the Star, or Planet to the Eaſt Part of the Horizon;

then ſee, what Degree of the Ecliptic is elevated above the Weſtern Horizon, according to the reſpective Arch of Viſion; then the oppoſite Degree on the Horizon, ſo found, compar'd with the Calendar, will ſhew you the Day requir'd. Thus for

EXAMPLE.

To the City of *Durham* on the 20th of *May* the *Ram's Horn* will be found to riſe *Heliacal.*

For the Setting.

If a Planet and its Place agrees with the Sun's, it will be then found to be the ſame as if it was a fix'd Star; which being accordingly brought to the Weſt Side of the Horizon, obſerve, to the Eaſt, what Degree is elevated equal to the known Arch of Viſion: Then, by the oppoſite Degree, will be found the Day ſought.

Thus, on the 15th of *October*, finding *Venus* in the 20th Degree of *Scorpio*, ſhe will be found in the Latitude of *London* to ſet *Heliacal.*

PROB. XII.

To find the Time of the Year when any known Star will riſe, or ſet, Coſmical.

For the Riſing.

Rectify the Globe to the given Latitude, then bring the Star to the Eaſt Part of the Horizon,

Horizon, ſee what Degree of the Ecliptic is cut by it, and anſwering to that Degree, in the Calendar, on the Horizon, you'll find the Day requir'd.

EXAMPLE.

At *York* I wou'd know when the *Lion*'s *Heart* riſes with the Sun.

In this you'll find the 26th Degree of *Leo* riſes with the given Star, which being conſider'd as the Sun's Place for that Time, you will find oppoſite to it on the Horizon, as requir'd, the 8th of *Auguſt*.

For the Setting.

Rectify the Globe as before, bring the given Star to the Weſtern Horizon, then obſerve what Degree of the Ecliptic is riſing to the Eaſt, and over-againſt it, as before, you'll find the Day requir'd.

Thus, by the foregoing Method, on the 28th of *March*, you'll find that in the Latitude of *London* the *Virgin's Spike* will ſet as the Sun riſes

PROB. XIII.

To find the Time when any Star will riſe or ſet Acronical.

For the Riſing.

The Globe being rectified, bring the given Star to the Horizon Eaſtward, then ſee what Degree of the Ecliptic is cut by the

Horizon Weſtward, and againſt it, in the Calendar, is the Day requir'd.

In this manner at *Edinburgh*, the bright Star in the Shoulder of *Orion*, will be found to riſe *acronical* on the 30th of *December*.

For the Setting.

The Globe being rectified as before, bring the ſaid Star to the Weſt Part of the Horizon, and look what Degree of the Ecliptic is then ſetting; and oppoſite to it, in the Calendar, is the Day ſought.

Thus you'll find in the Latitude of *London*, and on the 5th of *June*, *Procyon* will ſet with the Sun.

CHAP.

CHAP. XII.

Propoſitions more immediately ſolved by the Tereſtrial GLOBE.

PROB. I.

To find any particular Place on the Globe, by having the Latitude and Longitude of it given, and vice verſa, *&c.*

The RULE.

BRING the Degree and Minute of Longitude to the Meridian, then right under the given Latitude (North or South) you'll find the Place ſought for: And again, *vice verſa*, any particular Place being brought to the Meridian, the Latitude and Longitude may be found as above.

Thus you'll find the Latitude of *London* 51°: 30′ North. Its Longitude 0: 0; (as being accounted the firſt Meridian on all *Engliſh* Globes.)

of *Conſtantinople* Latitude, 41° : 6′
——— Longitude, 28° : 55′

COROLLARY.

All thoſe Places that, by turning round the Globe, paſs under the ſame Degree, are

in the ſame Parallel of Latitude; and in the ſame manner, thoſe that lie in the ſame Meridian, have the ſame Degree of Longitude.

If the Difference of Latitude or of Longitude betwixt any two Places be requir'd, then

When they are of { * the ſame / † a different } Kind { their Difference / their Sum } ſhew it.

PROB. II.

To find the true Diſtance betwixt any two Places on the Globe, and all thoſe Places of the ſame Extent from each.

The RULE.

If both Places lie under the ſame Meridian, their Difference of Latitude is the Diſtance requir'd; but if they are in one and the ſame Parallel, or if they differ both in Latitude and Longitude, then the RULE is thus;

Lay the Quadrant of Altitude upon both the given Places, and the Degrees intercepted, converted into Miles ‡ will be the Diſtance required.

Thus

* *i. e.* Both North or both South, both Eaſt or both Weſt.

† One North the other South, or one Eaſt, the other Weſt.

‡ 60 Geographical Miles is equal to one Degree, but of Geometrical Miles 69, 5: therefore if you would reduce any Number of Degrees, into *Engliſh* Miles, multiply them by the latter.

Thus the Diſtance betwixt *London* and *Rome* will be found nearly 980 *Britiſh* Miles, betwixt the *Lizard* and the Iſland of *Barbadoes* 3900, and betwixt *Edinburgh* and *Madrid* 1111.

COROLLARY.

If a Circle be deſcrib'd, at a given Diſtance, from any one Place, either by the Quadrant of Poſition, or a Pair of Compaſſes, it will paſs over all thoſe Places that are of the ſame Extent from the ſaid Place.

PROB. III.

To find the Bearing of one Place from another, and alſo their Angles of Poſition.

LEMMA.

If both the given Places lie in one Parallel, their Bearing is either Eaſt or Weſt from each other; if, under the ſame Meridian, they are North and South from each other: But if a Rhomb Line paſs through both of them, then their Bearing is ſhewn thereby, and is of the ſame Name with it, either direct or contrary.

If a Rhomb Line does not paſs through either of them, ſee to which the given Places are neareſt Parallel, and accordingly that will be the Bearing ſought.

Thus the Bearing of the *Heſperides*, from the Iſland of *Bermudas*, will be found nearly W. N. W.

To find the Angle of Poſition.

Bring one of the given Places to the Brazen Meridian, and rectify the Globe to that Vertex; then the Quadrant of Altitude being fix'd to the Zenith, turn its graduated Edge to the other Place; that done, the Degrees now contained betwixt it and the Meridian, in the Horizon, is the Angle ſought.

Thus the Angle of Poſition from the *Lizard* to the Iſland of *Barbadoes*, will be nearly 71 Degrees South-weſterly.

N. B. The Angle is not the ſame back again, as the oppoſite Points of Rhombs are, but variouſly different; as will appear by this Example. For the North Poſition varies from the South near 34°; ſo that the Angle of Poſition from *Barbadoes* back to the *Lizard*, will be only 37° N. E.

PROB. IV.

To find, at any time, to what Part of the World the Sun is Vertical, where it is Riſing, Setting, &c.

LEMMA.

The Latitude of the Place, where the Sun is Vertical, is always equal to the Sun's Declination, and its Longitude from the given Place to the Time from Noon, in that Place. Therefore,

After

After having brought the Place you account from to the Meridian, and fix'd the Index to the given Time, if you turn the Globe till the Index ſtands at 12 o' clock, right under the Declination in the Meridian, is the Place required to be found.

Again, if you would know the Sun's preſent Altitude at any other Place, bring the ſaid Vertex to the Zenith, *i. e.* rectify the Globe for that Latitude, and keep the ſaid Place in the Meridian.

Then, to all thoſe Places, at the Weſtern Horizon, the Sun is riſing, to thoſe on the Eaſt he is juſt ſetting; to thoſe above the Horizon the Sun is elevated as they themſelves are on the Globe: Thoſe on the Weſt Side of the Meridian have Morning, to whom the Sun is aſcending; to thoſe on the Eaſt Side he is deſcending, where it is Evening; and to thoſe under the Diurnal Meridian, it is exactly Noon or Mid-day.

The Sun's Altitude, to any one Place, is always equal to its own Elevation above the Solar Horizon, (which in this caſe is the Wooden Frame) and at any time may eaſily be found by rectifying the Quadrant.

Every Place below the Horizon has different Degrees of Darkneſs, according to their Diſtance from it. Thoſe within 18 Degrees of the Horizon, all round the Globe, have Twilight; thoſe in the Nocturnal Meridian below, have total Darkneſs, or Mid-

night;

night; to thoſe juſt 18° below the Horizon weſtward, the Dawn, or Day-break, is juſt appearing; and to thoſe, as much depreſt below the Eaſtern Plain, the Day-light is juſt departing.

PROB. V.

To explain the Viciſſitude of Day and Night, and in general the Diverſity of Seaſons; alſo to repreſent, at one View, the Path of every Vertex, and the true Proportion of Light to all the Inhabitants of the World.

LEMMA.

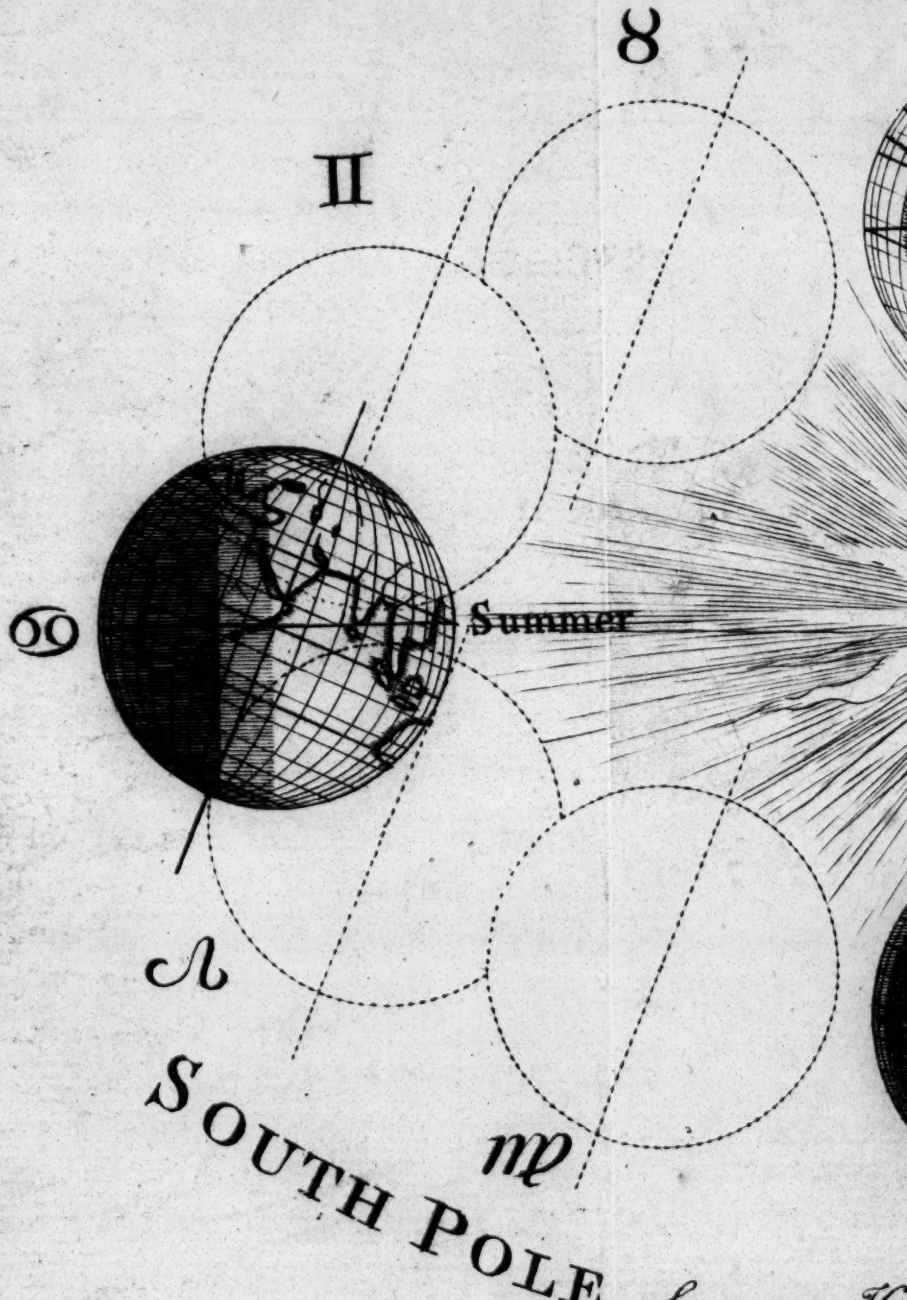
All the Inhabitants of the Earth do equally enjoy the Sun's Light in reſpect of Time, and are equally deprived of it at the contrary Seaſons; and as the Sun continues always to enlighten one half of it, if there was no Refraction, it would be intirely abſent from the other at that time.

The illuminated Hemiſphere is that of the Day, and the opaque one that of Night.

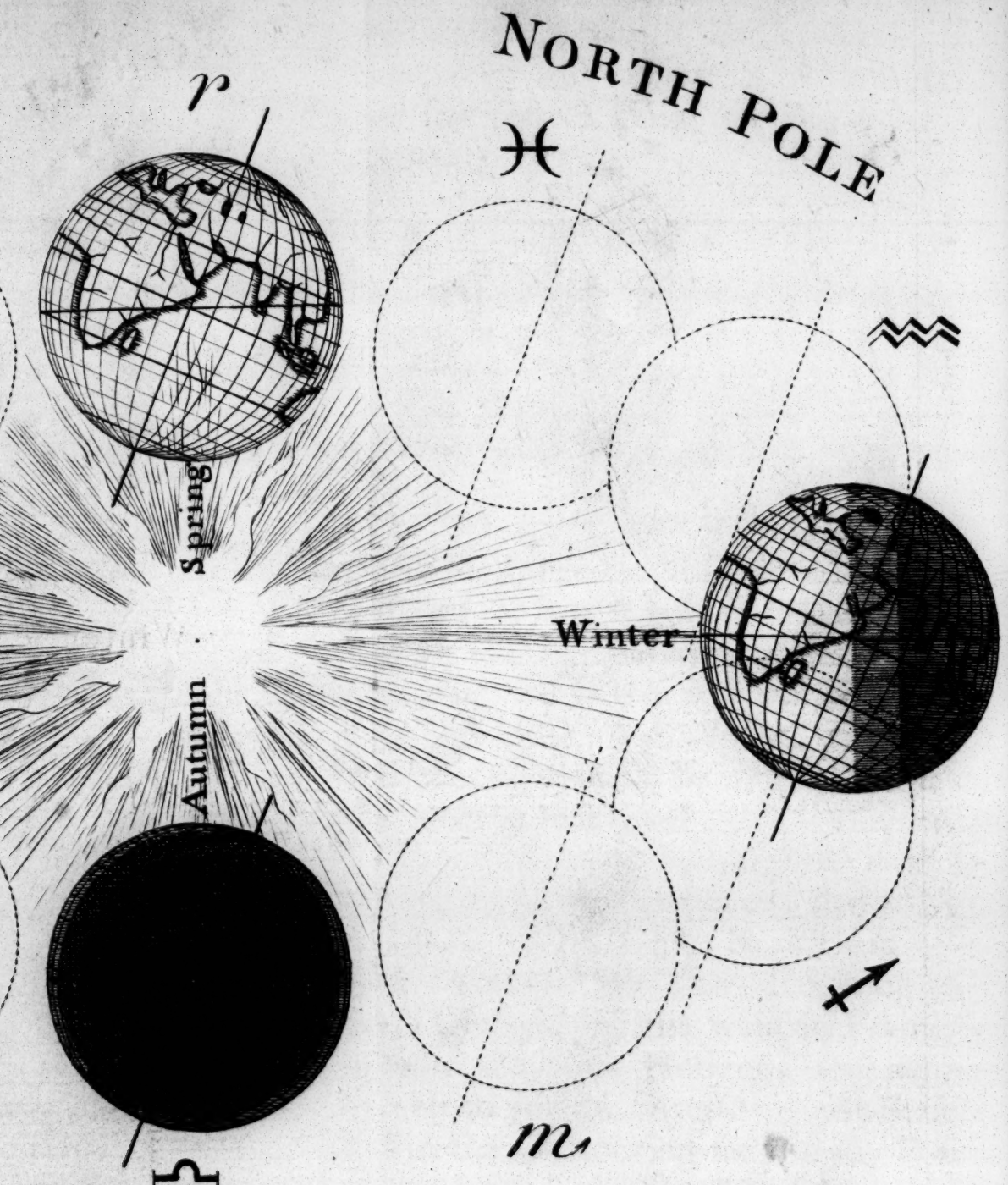
Hence, if the Globe be rectified at different times of the Year, according to the Sun's Declination, the wooden Frame will become the Solar Horizon, and naturally exhibit to you the Diverſity of the Seaſons.

For the Globe being fix'd in any Poſition of this kind, every Parallel of Latitude will be divided into two Parts, one call'd the Diurnal, the other the Nocturnal Arch; each

The cauſe of the Viciſsitude of Seaſons



Some say, He
The Poles of t
From the Sun's
Oblique, the cen



. He bid his Angels, turn ascance
of Earth, twice ten degrees and more,
Sun's Axle; They, with labour, push'd
e central Globe. Milton B. X.

each ſimilar to the correſponding Day and Night. Therefore, if the Poles of the World be continually elevated, or depreſt ſo as to bring the Sun's Place ſucceſſively to the Zenith, according to his progreſſive Motion in the Ecliptic, you may, at one View, by giving the Globe a ſlow Motion upon its Axis, obſerve in all Parts of the World the general Alteration, and Return of the Seaſons; the gradual Increaſe, and Decreaſe of every Diurnal, and Nocturnal Parallel, or Path of any Vertices; the Progreſs and Poſition of any Place as it travels Eaſt; the Viciſſitude of Light and Shade; and the univerſal Length of Day and Night. Plate XV.

PROB. VI.

To explain the Temporary Difference of Meridians, &c.

From what has been ſaid it may be obſerved, that the Hour of the Day, to all Parts of the World, at any one Inſtant of Time, is not the ſame; but varies in different Places according to the Difference of Longitude. Thoſe to the Eaſt have Day ſooner, and thoſe to the Weſt have it later, than the Place accounted from. Now 15 Degrees of the Equator, being equal to one Hour's Motion in the Equinox, if any Place lie Eaſt from another 30 Degrees, there will be two Hours Difference in their Account of Time;

Time; conſequently, when 'tis Noon at the Eaſtermoſt, it will be but 10 o'clock in the Morning, at the Weſtermoſt. Thus the Difference of Longitude being given in Degrees, and reduc'd into Time, as above, the Hour of the Day at any one Place, may be eaſily known all over the World.

For EXAMPLE.

I would know the Hour of the Day at *Conſtantinople*, when 'tis 9 o'clock in the Morning at *London*.

By the GLOBE.

Having brought *London* to the Meridian, and placed the Index to the given Hour there, bring *Conſtantinople* to the Meridian, then will the Index point to the Time here; which you'll find to be 7′ paſt 11.

The like is to be underſtood of all others, and may be found in the ſame manner. So when it is 12 o'clock at *London*,

Plate XII.

At	*Mexico*	it will	6 : 30	in the	
	Port Royal		5 : 30	Morning.	
	Vera Cruz				
	Pequin	be	7 : 50	in the	
	Surat		5	Evening.	
	Agra				

PROB.

PROB. VII.

By knowing the Time of any particular Phænomenon, to find its Poſition in the Heavens, and where it may be viſible.

The RULE.

Bring that Part of the Globe, to which the Sun, Moon, or Planet will be Vertical at the given Time, to the Zenith; then will ſuch Phænomena as are momentary, be viſible to all the Inhabitants of the Earth that are now above the Horizon: and if you rectify the Quadrant, and lay it over every particular Place, it will ſhew the Altitude of it; as alſo the Azimuth; oppoſite to which in the Heavens, is the vertic Circle, in which the Object will be found.

Thus the middle Poſition of an Eclipſe, Tranſit, or Occultation of the heavenly Bodies, may be nearly determin'd, to any given Place upon Earth: but for the Beginning, and End of the ſame, a new Operation will be required.

PROB. VIII.

To find, by the Globe, a true Meridian Line, and to explain the moſt natural Principle of Dialing.

The RULE.

Place the Globe upon an horizontal Plain, and (by Prob. X.) obſerve two equal Altitudes

tudes of the Sun at different times, one before, the other after the Meridian *; and at each Obſervation, draw a Line parallel to the Meridian; which done, take away the Globe, and continue thoſe Lines, till they meet or interſect each other; then will the Line biſecting this Angle, be a true Meridian.

However, Care is required in turning the Globe about from the firſt to the ſecond Obſervation; becauſe the leſs it is removed out of its Place, 'twill be the leſs ſubject to Error.

COROLLARIES *relating to* Horologiography.

I. If any Tereſtrial Globe be taken out of the Frame, and fix'd upon a Pin due North and South, in any open Place, the Pole being elevated to the Latitude, and the Place of the Obſerver upon the Globe turn'd to the Vertex, it will reſt upon its proper Nadir Point, and repreſent a true Convex Dial: On which, if Meridians be drawn thro' every 15° of the Equator, and mark'd accordingly with the correſpondent Hours, as at A, *&c.* it will ſhew (alternately by the Interſection of

* Notwithſtanding there is a ſmall Error in the above Theory, ariſing from the Sun's Declination, when he is in, or near either of the Tropics; yet if obſerv'd with *proper Inſtruments*, eſpecially about the Time of the Equinoxes, it will come very near the Truth.

of Light and Shade) when the Sun ſhines upon it, the exact Time of the Day all the Year round; alſo to what Part of the World the Sun is Vertical; where he is Riſing, or Setting, or in the Meridian; conſequently, where 'tis Day, Night, Evening, or Morning; Noon, Midnight, Twilight, *&c.*

II. If ſuch a Convex Dial be cut by a Plain, to repreſent the Horizon, Lines drawn from the Center to the ſeveral Meridians, at the Surface, will be the true Hour-lines of an Horizontal Dial in that Latitude: And the Axis, if remaining as continu'd, will be the Gnomon. (See the Fig. at C.)

In like manner will the prime Vertical Plain become a direct South, or North Dial; as any other Vertical Plain may become an erect Decliner according as its Poſition is oriental or occidental. (Fig. B.)

In like manner, an oblique Plain, will become either

A Reclining An Inclining Or a Polar	Dial,	ſuch as	Fig. 1ſt. 2d. 3d.	Pla. XIII.

Thus, all kinds of Sun-Dials may be made from a Globe, except that of the Equinoctial, and thoſe of the Eaſt, and Weſt; which Plains paſſing thro' the Poles, would never interſect the Hour-Circles, and there-

fore require each a new Projection, and a ſuper-natural Stile.

N. B. The manner of projecting theſe ſeveral ſorts of Dials is repreſented in Plate XIV. Fig. 1. and 2.

III. If the Impreſſion of a Globe be revers'd, and one Half, or Hemiſphere, (every way 90 Degrees from any Place,) be paſted into a true horizontal Concave, with Hour-Lines, Azimuths, and Almicanthers, proper to the Place; and a ſtraight Pin, or Wire, with a Ball upon it, be fix'd in the Pole to repreſent the Axis and Center of the Earth; it will, (when juſtly placed) exhibit all the Requiſites in Dialing; as the Hour of the Day, the Sun's Altitude, Azimuth, and Declination; his Amplitude, Riſing, and Setting; the Length of the Day in *Babyloniſh*, *Italian*, and *Jewiſh* Hours; and the Sun's perpendicular Way over the ſeveral Countries, at all times of the Year.

N. B. This is the moſt natural of all Dials, and may be peculiarly adapted to any of the Poſitions, mentioned on the other ſide.

CHAP.

CHAP. XIII.

Some general and universal THEOREMS *from the foregoing* PROPOSITIONS, *viz.* That

I. ALL the Inhabitants of the Earth do equally enjoy the Sun's Light, in respect of Time, and are equally depriv'd of it.

II. In all Parts of the Globe, betwixt the Equator and the Poles, the Days and Nights are never equal, but when the Sun is in the Equinoctial.

III. Under the Equinoctial, the Days and Nights are equal at all times of the Year, and no where else.

IV. The nearer any Place is to the Equator, the less is the Difference, in Time, betwixt the artificial Day and Night.

V. To all the Inhabitants living under one and the same Parallel, the Days and Nights are equal.

VI. To all Places within the Torrid Zone, the Sun is Vertical twice a Year; to those under the Tropicks once; but in any other Place never.

VII. In all Places lying betwixt the Polar Circles and the Poles, the Sun, at a certain time of the Year, continues for ſeveral Days above the Horizon without ſetting, and at the oppoſite Seaſon, is as long without riſing; and the nearer to, or farther remote, any Places are from the Poles, the longer, or ſhorter, is the Time of the Sun's apparent Preſence to, or Abſence from the ſame.

VIII. The greateſt Latitude of any Place is, that of 90 Degrees or, under the Poles.

IX. The greateſt Longitude of the ſame is that of 180°. Counted in

X. The Equator, which in that caſe is call'd the *Signifier*.

XI. The Latitude of any Place is equal to the Pole's Elevation.

XII. The Diſtance of the Pole from the Zenith is equal to the Height of the Equinoctial above the Horizon, and is the Complement of the Latitude.

XIII. If it was poſſible for a Ship to ſail quite round the Globe directly North, and South, the ſaid Ship wou'd continually change her Latitude, without the leaſt Deviation from the Meridian departed from; conſequently, at her Return the People of the Ship would not differ in the Account of Time,

Time, from the Inhabitants reſiding in the Place departed from.

XIV. If a Ship was to ſail quite round the Globe, due Eaſt, or Weſt, the ſaid Ship wou'd perpetually change her Longitude, but not in the leaſt her Parallel of Latitude; and at her Return to the Place of her firſt ſetting ſail, by the firſt Courſe, ſhe would gain, and by the ſecond, loſe a compleat natural Day in the Account of Time; *i. e.* in the former the People of the Ship would reckon a Day more, and in the latter a Day leſs, than the Inhabitants of the Place departed from.

XV. If a Ship was to ſail in any oblique Direction, its Latitude and Longitude both wou'd alter.

XVI. The Inhabitants of the Eaſtern *China* account their Time much ſooner than thoſe reſiding to the Weſt.

XVII. No Place is diſtant from another above 12518 Miles: The Diameter of the Earth being 7969 Miles.

XVIII. The viſible Horizon changes as we remove our Station.

XIX. The Length of the Morning and Evening Twilight, increaſes from the Equator to each Pole.

XX. The Amplitude of the Sun, increaſes with the Latitude and Declination.

The END of the Uſe *of the* GLOBES.

A Catalogue *of* GLOBES *and* MAPS, *made and ſold by* JOHNSENEX, Fellow of the ROYAL SOCIETY; *at the* Globe, *againſt St.* Dunſtan's *Church in* Fleet-ſtreet, LONDON.

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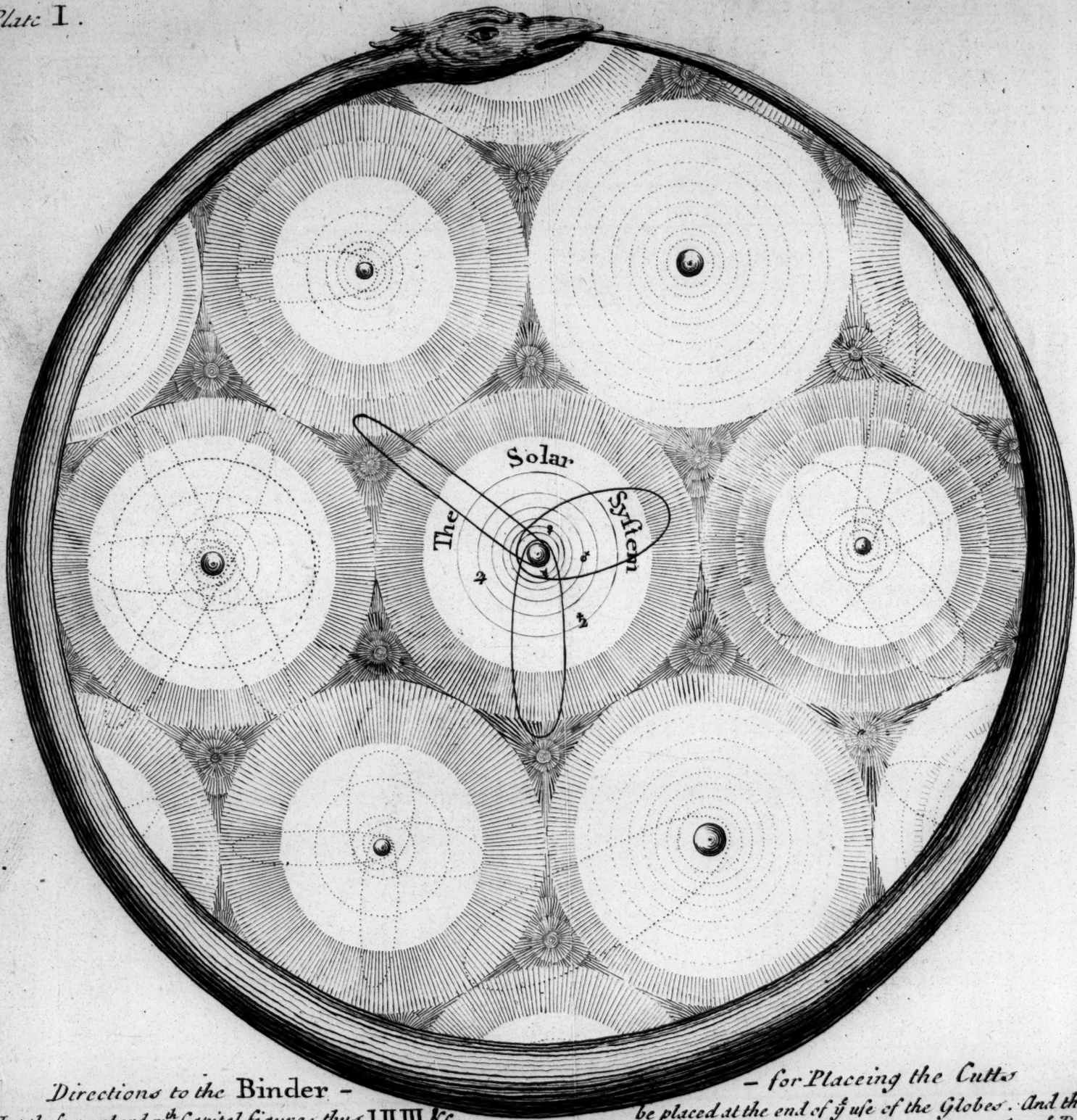
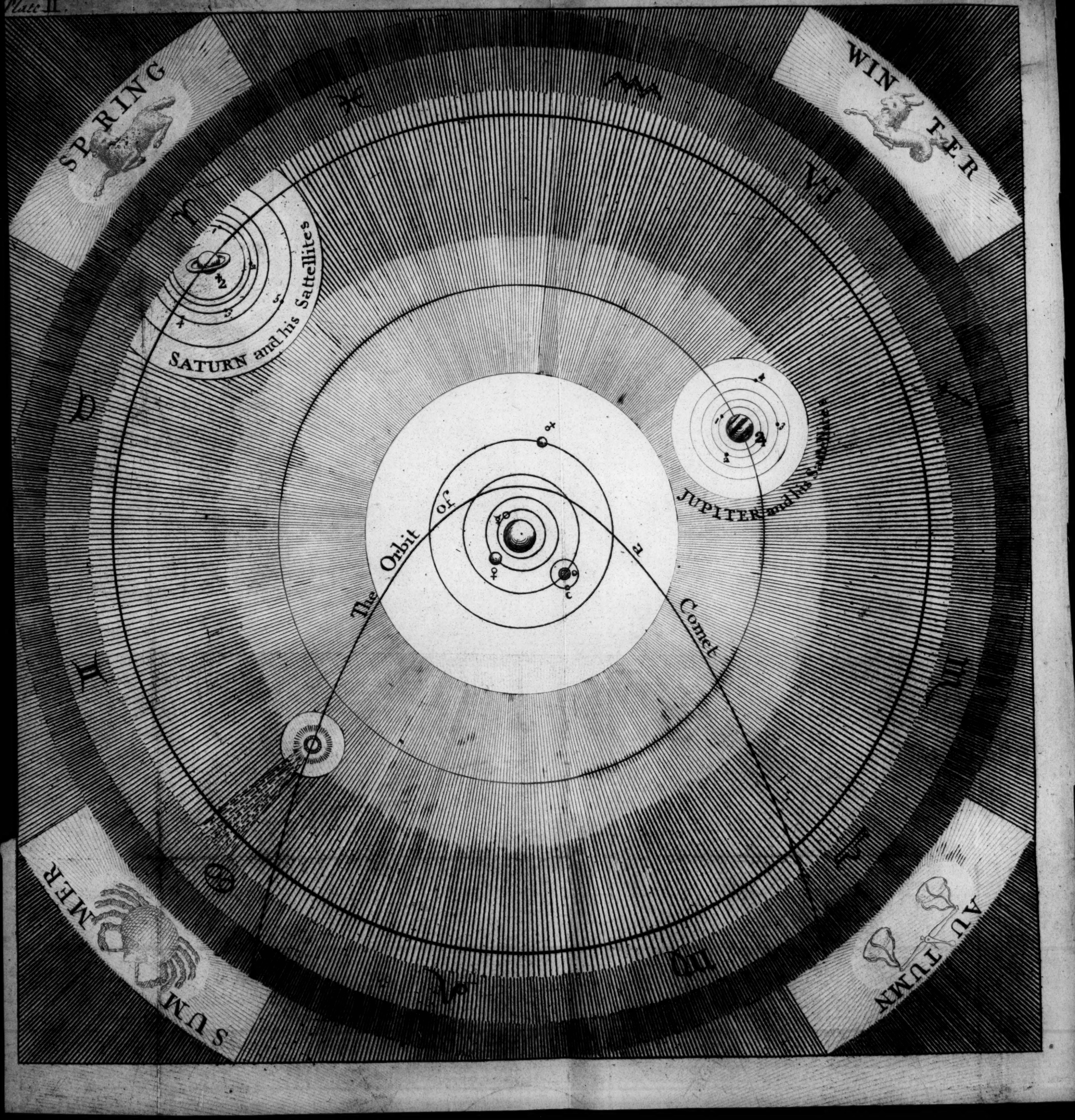
Plate I.



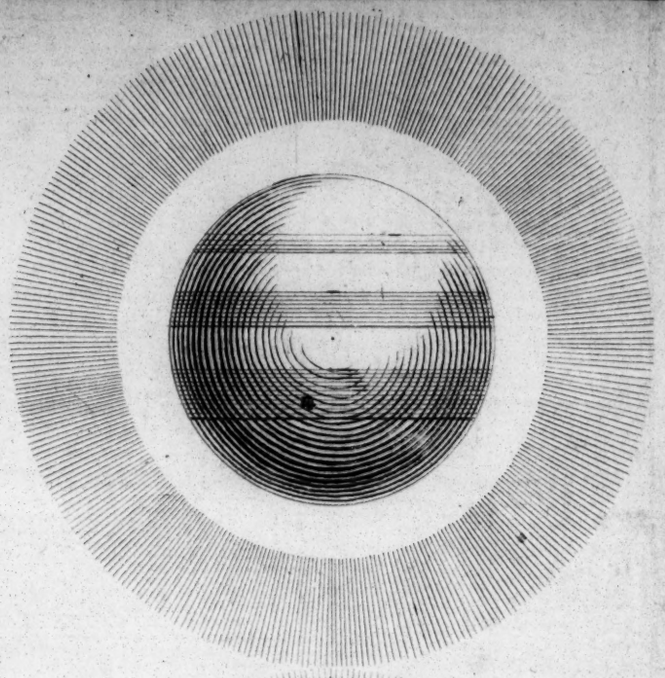
Directions to the Binder – *for Placeing the Cutts*

Let those numberd w^th Capital figures thus I.II.III *&c. be placed at the end of y^e use of the Globes. And those Numberd with small figures thus 1. 2. 3 &c be placed at the end of y^e doctrine of Eclipses. The others as directed to y^e Page.*

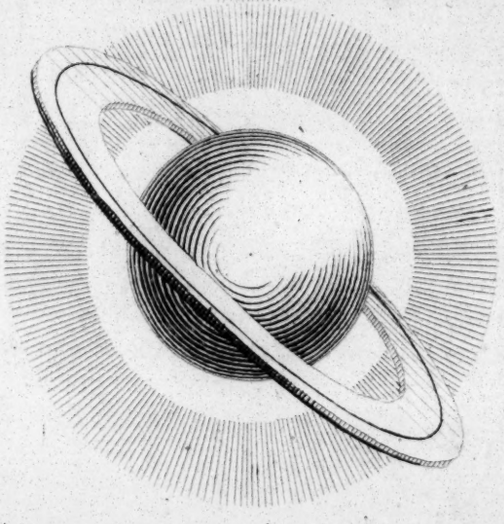
Plate II.


SPRING
WIN TER
SATURN and his Sattellites
JUPITER and his Satellites
The Orbit of
Comet
SUM MER
AU TUMN

♃
JUPITER



♄
SATURN.....



☉
The EARTH.....

VENUS.....♀.....

MARS.....♂.....

MERCURY..☿.....

The MOON.....☾.....

Plate IV.

Fig. 1.

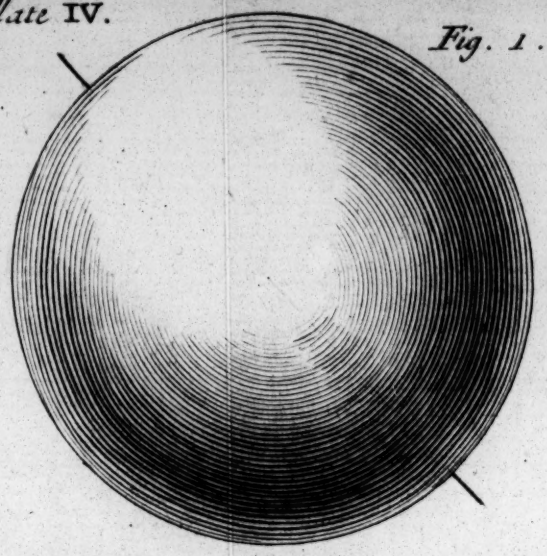


Fig. 3.

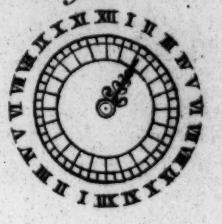
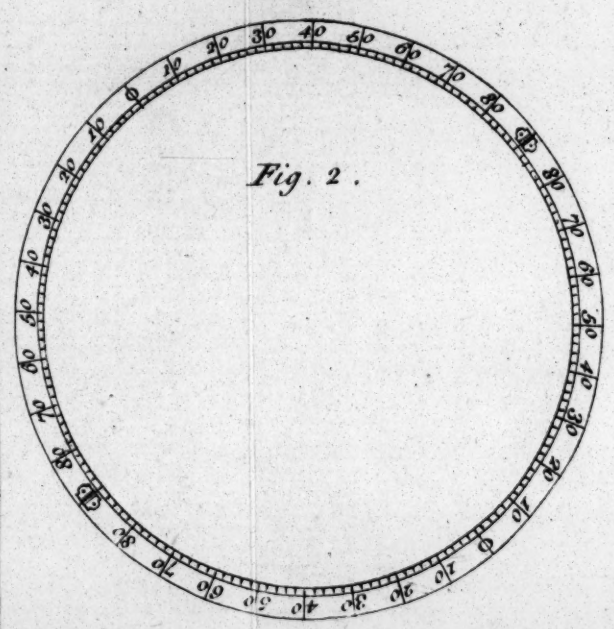


Fig. 4.

Fig. 2.



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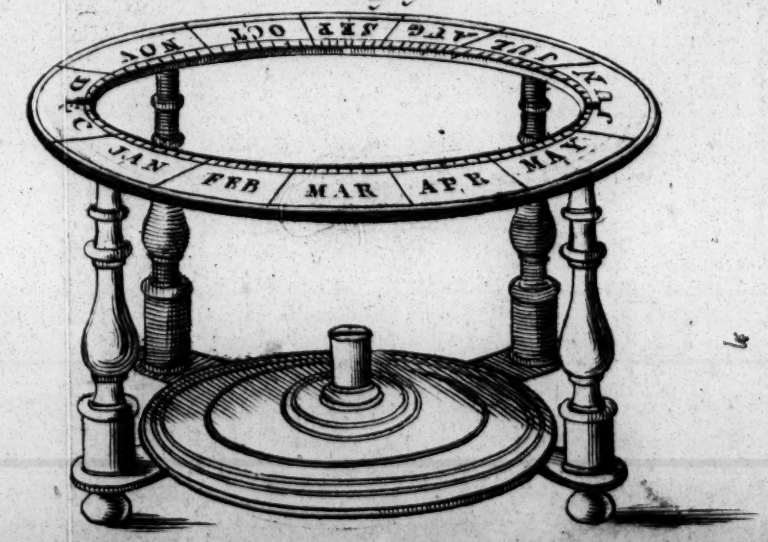


Plate V.

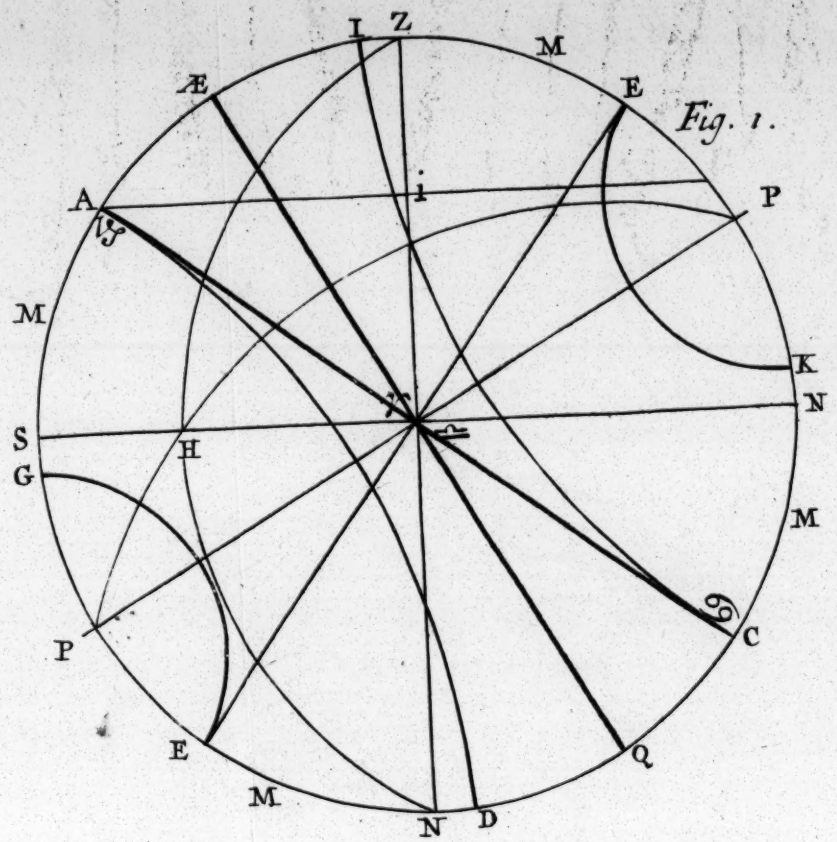
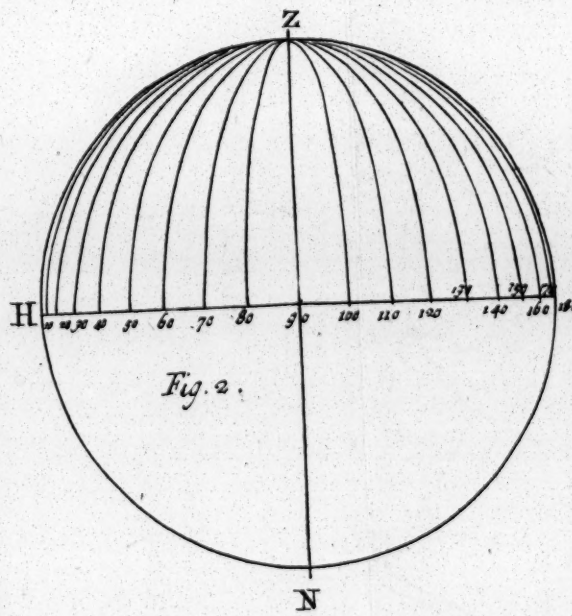


Fig. 1.



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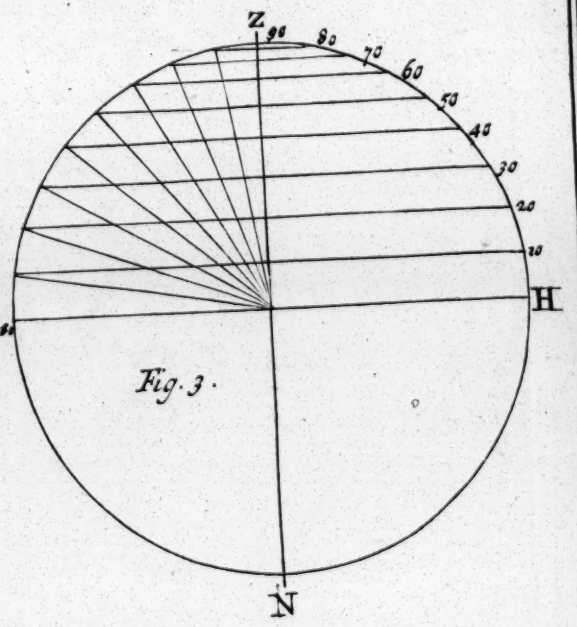


Fig. 3.

Plate VI.

Fig. 1.

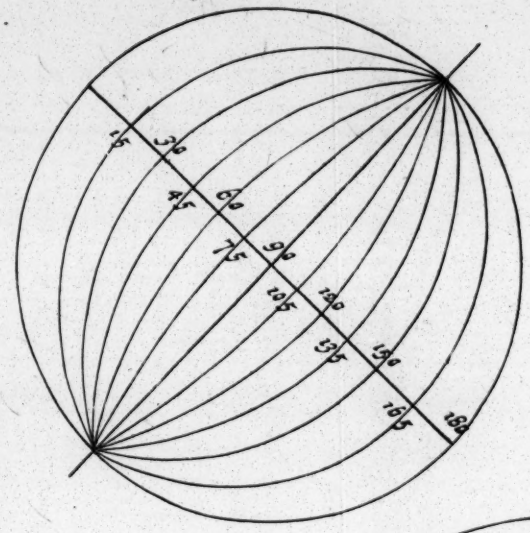


Fig. 2.

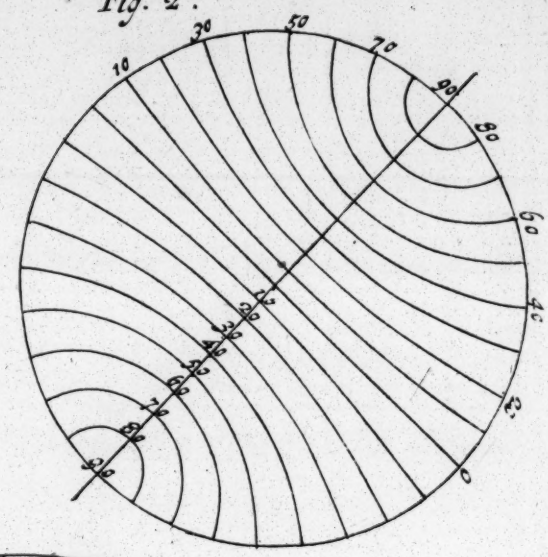
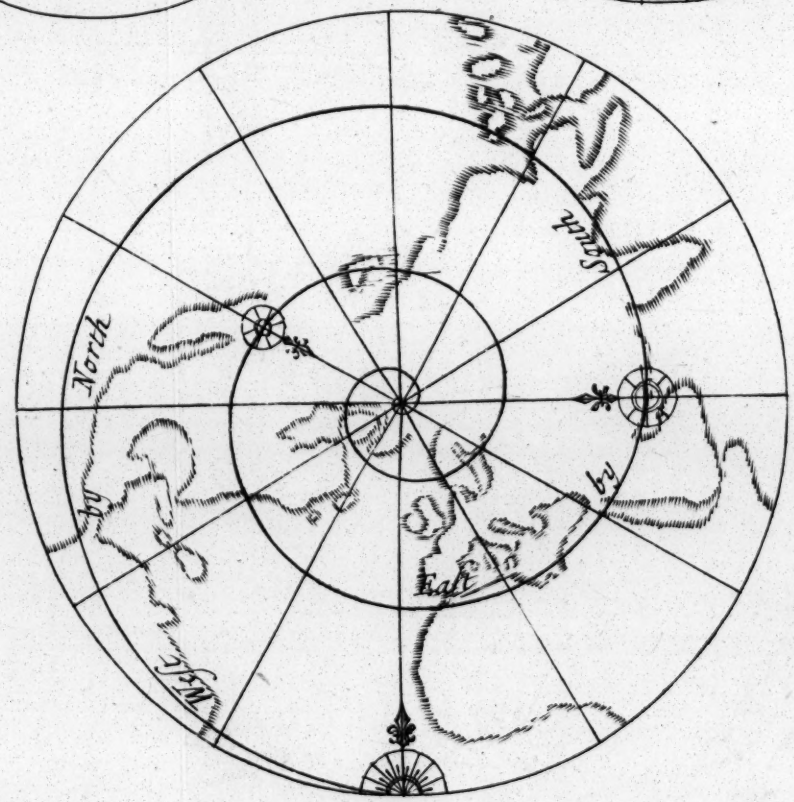


Fig. 3.



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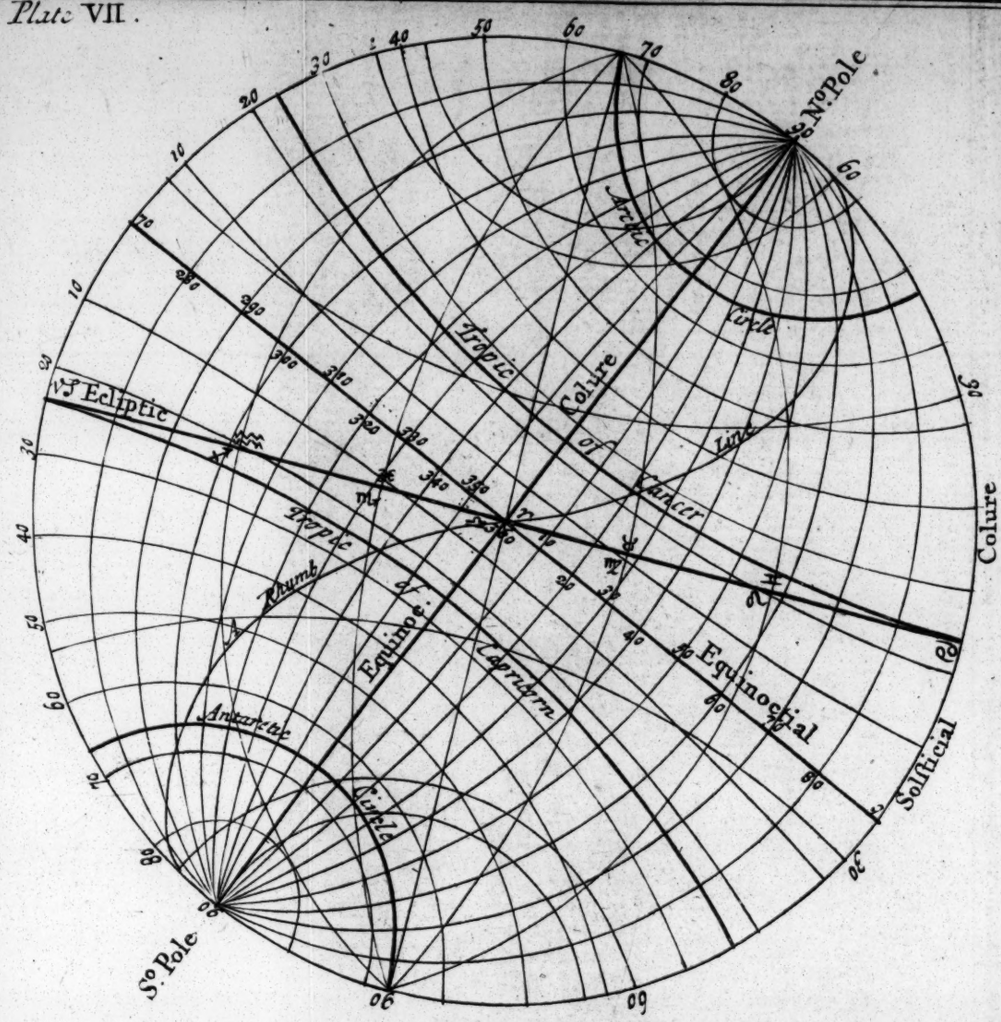
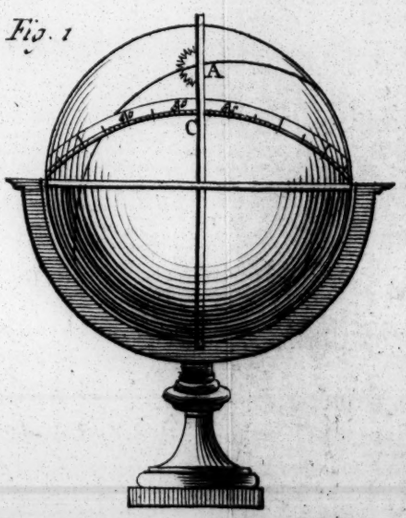


Fig. 1



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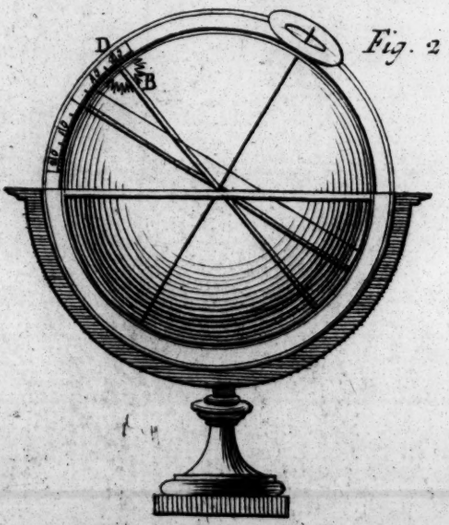


Plate VIII.

Fig. 2.

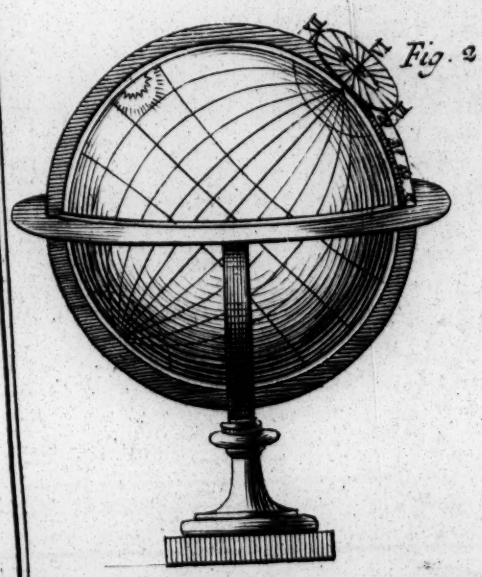


Fig. 3.

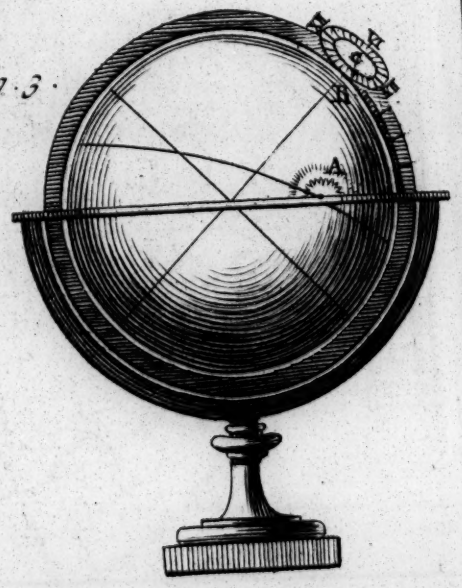


Plate IX

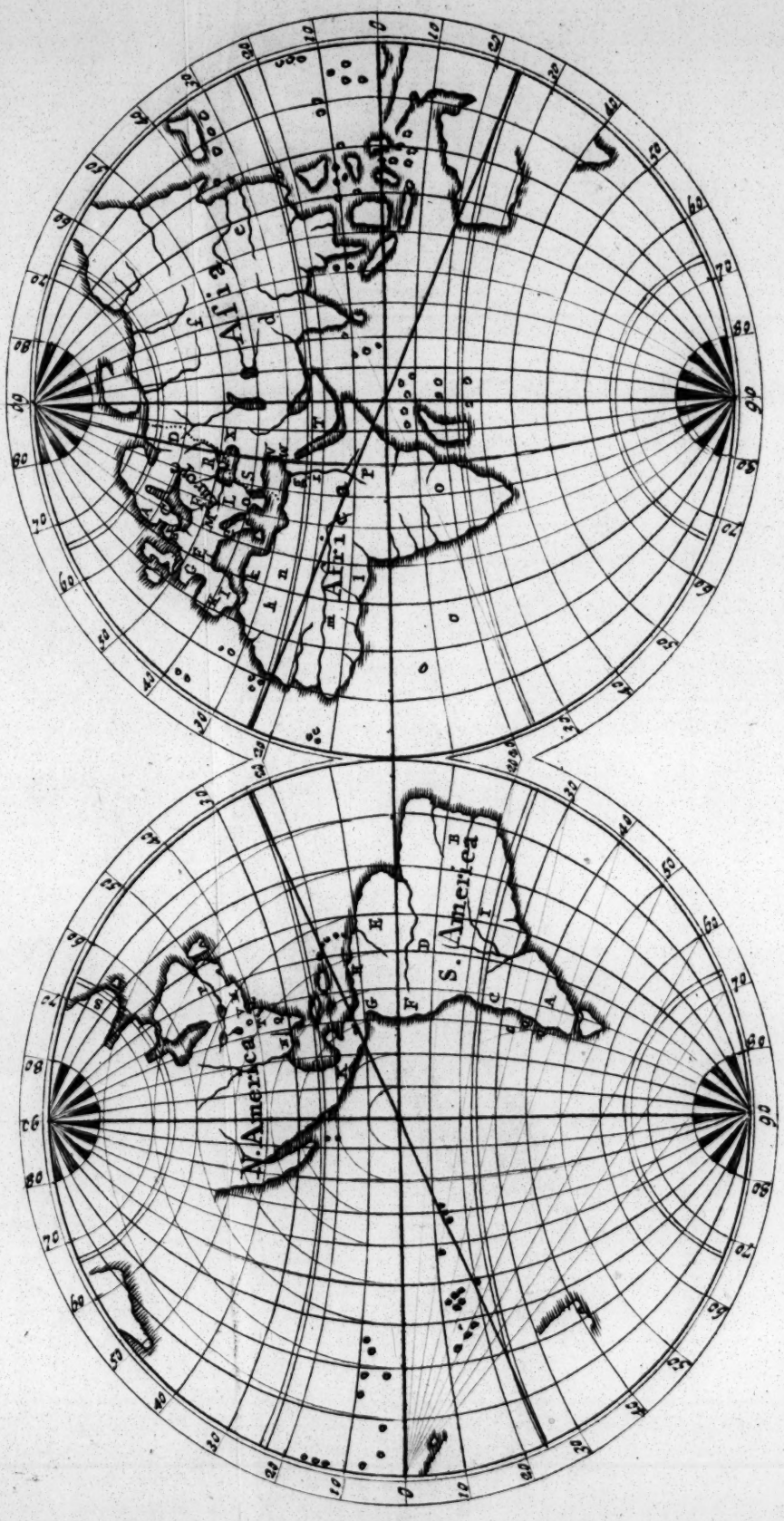


Plate X.

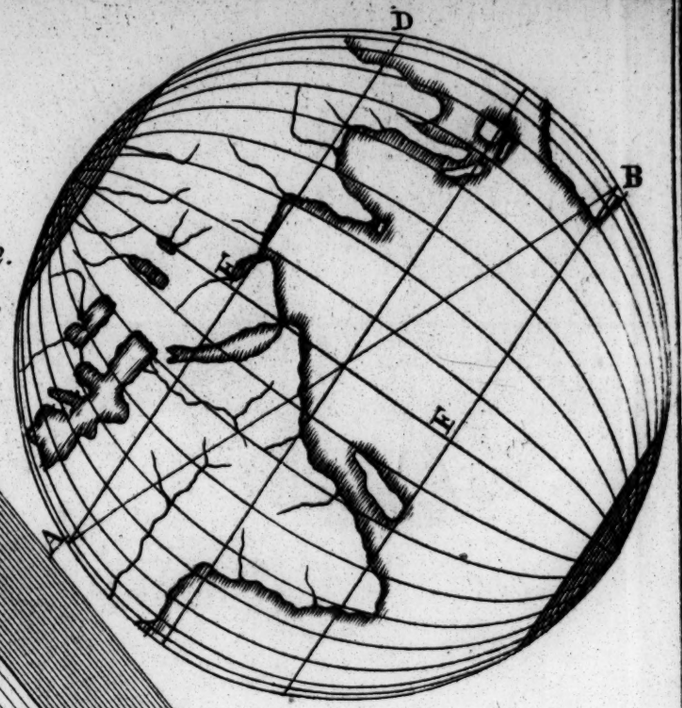


Fig. 2.

Fig. 1.

Plate XI.

A Parallel SPHERE
Fig. 1.

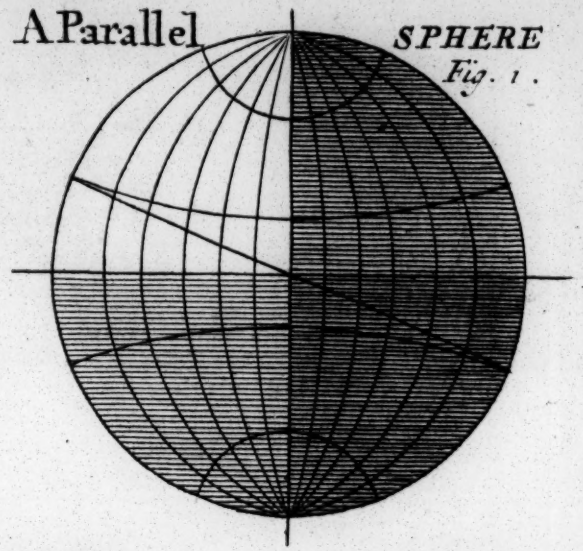
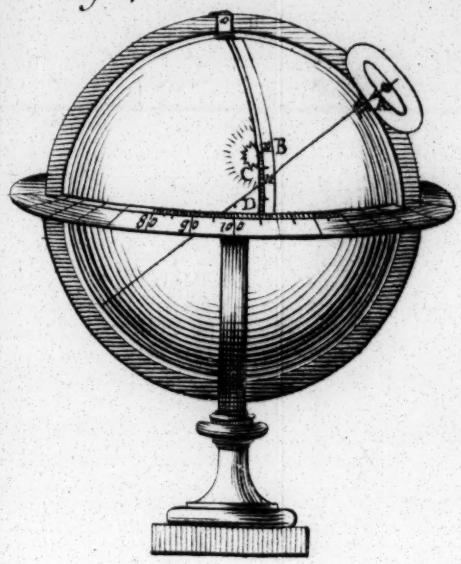


Fig. 4.



An Oblique SPHERE
Fig. 2.

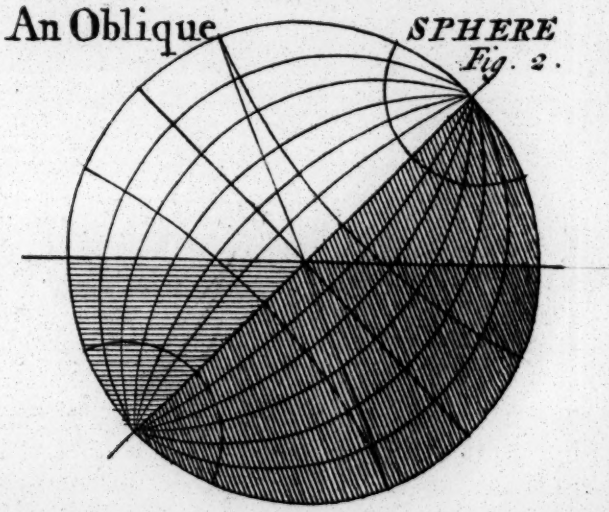
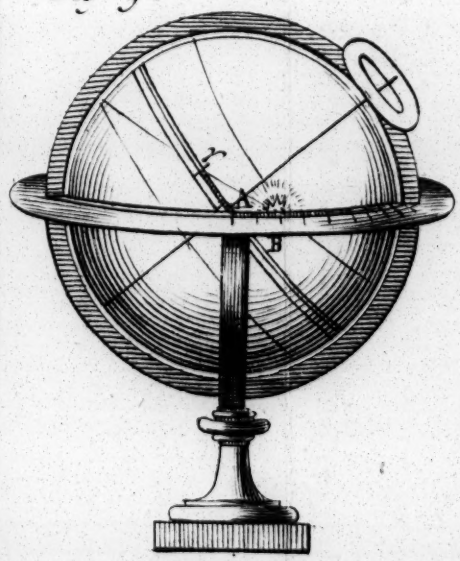


Fig. 5.



A Direct SPHERE
Fig. 3.

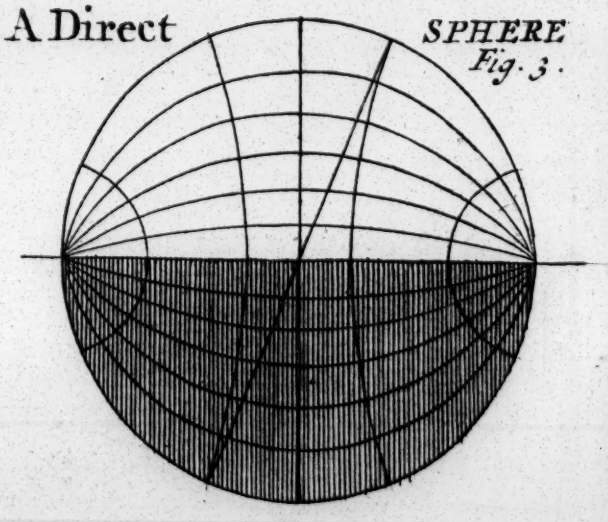
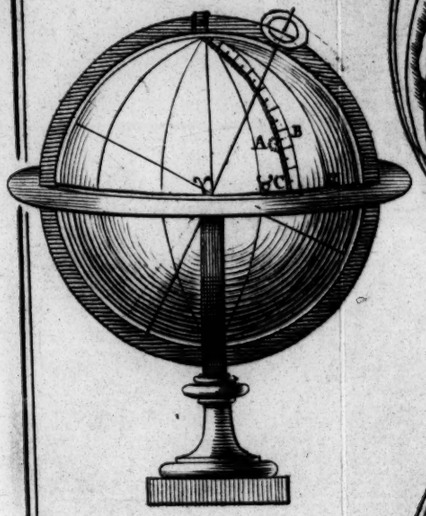
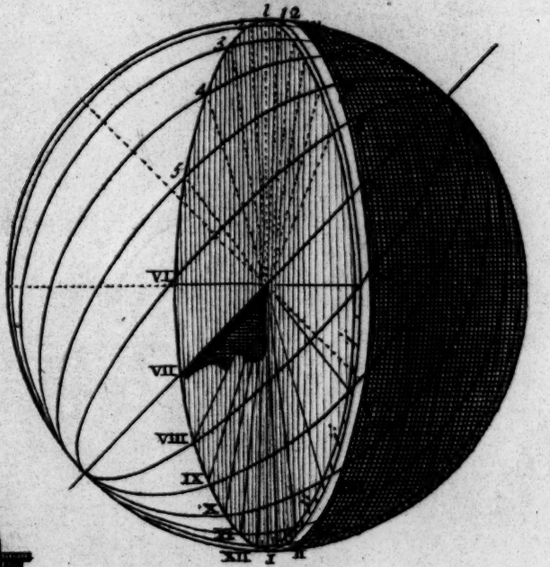


Plate XII.

Fig. 4.

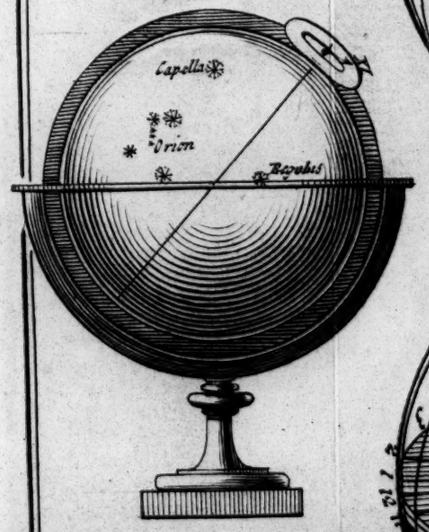


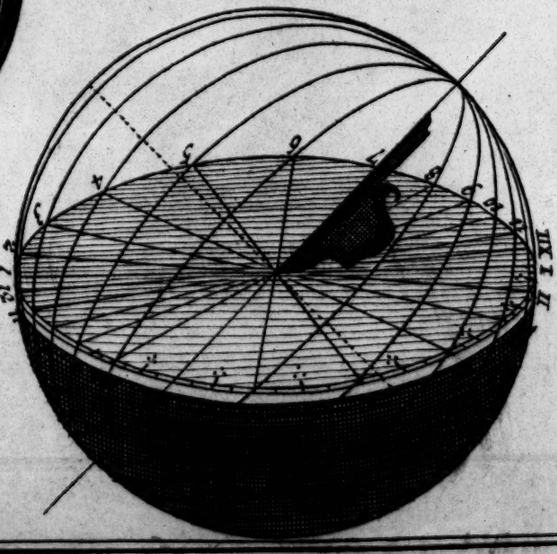
A



B

Fig. 5.





C

Plate XIII

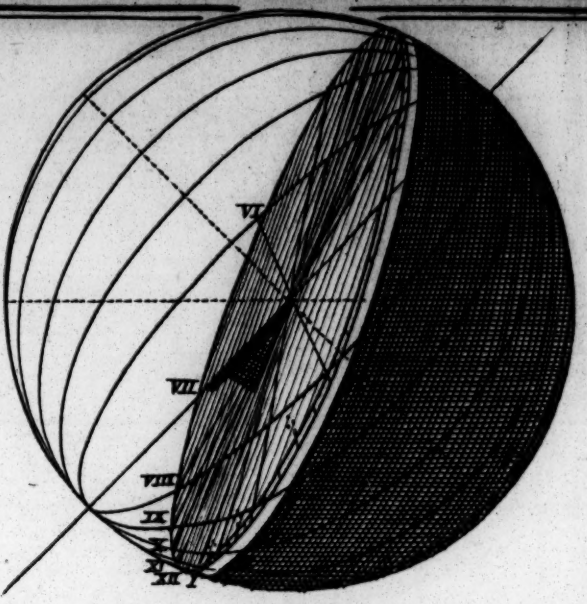
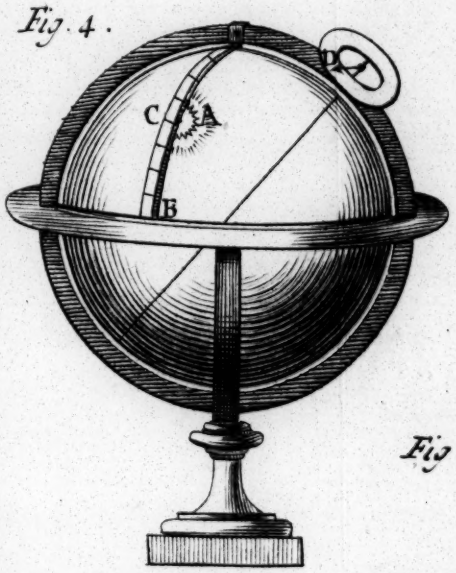


Fig. 1.

Fig. 4.



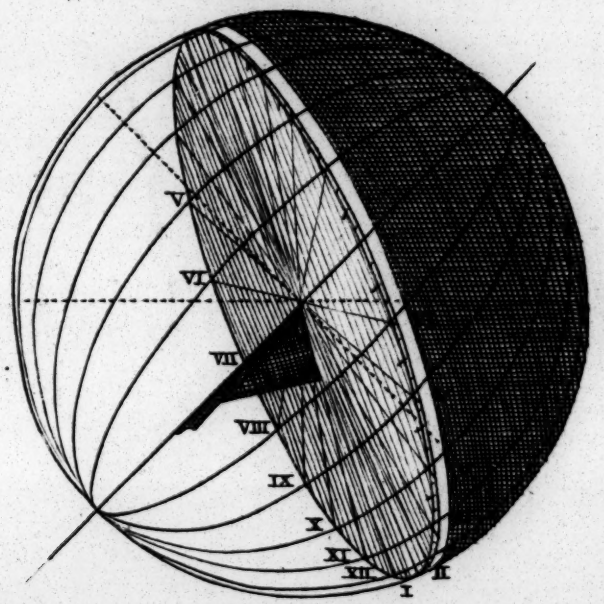


Fig. 2.

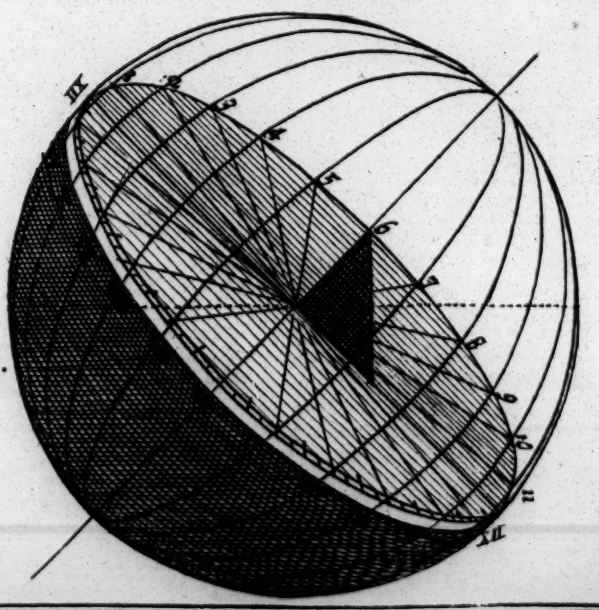


Fig. 3.

Plate XIV

A Projection of the Sphere upon ye Plain of ye Horizon or an Horizontal Dial in the Latitude 38.30.

Alſo

A Projection of ye Sphere upon the Prime Vertix and a South Dial in the Latitude 51.30.

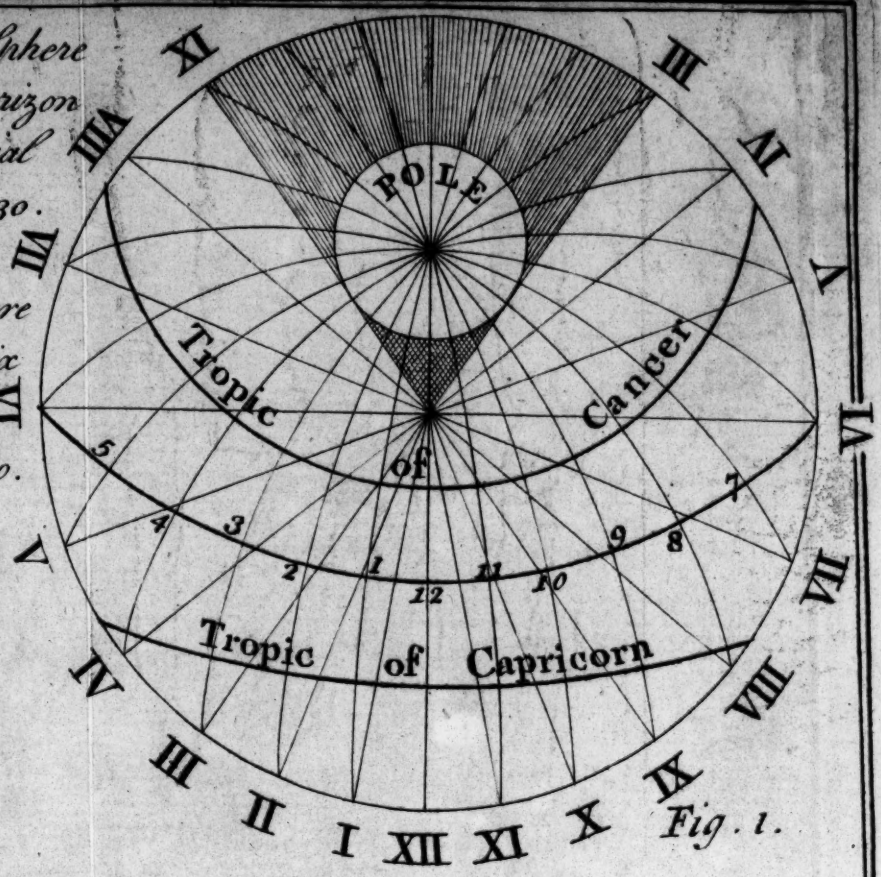
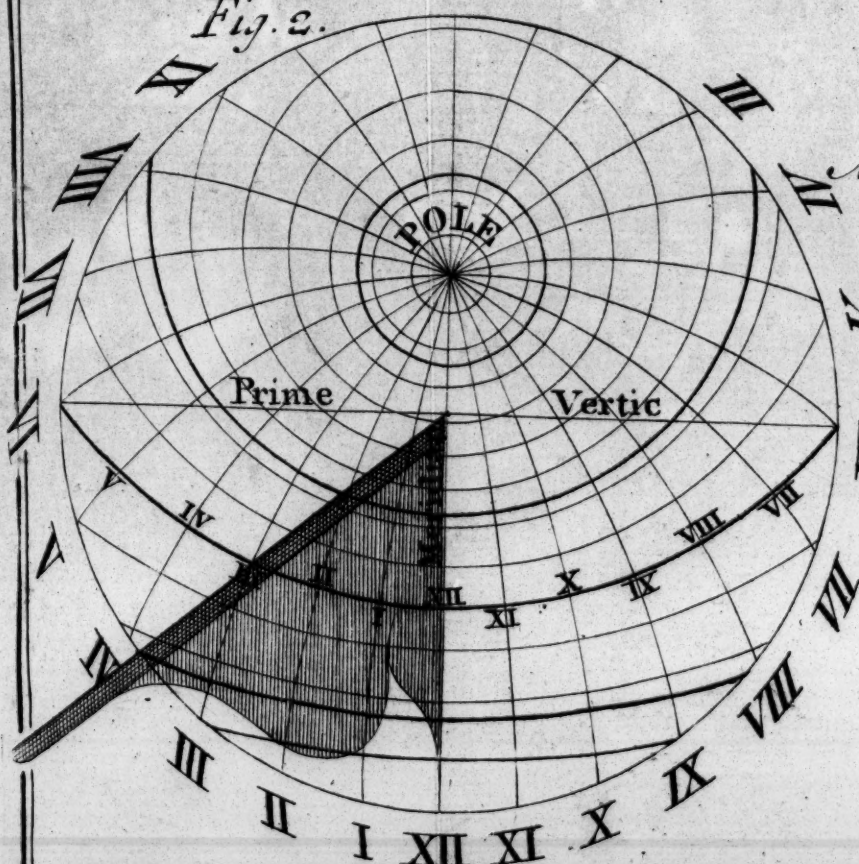


Fig. 1.

Fig. 2.



A Projection of ye Sphere upon the Plain of the Horizon in Latitude 51.30.

Alſo

A South Erect Direct Dial in the Latitude 38.30

A

SYNOPSIS

OF THE

DOCTRINE

OF

ECLIPSES.

THE DOCTRINE OF ECLIPSES.

CHAP. I.

THERE is nothing in Aſtronomy more worthy of our Contemplation, nor is there any thing more ſublime in natural Knowledge, than rightly underſtanding the ſudden Obſcuration of the heavenly Bodies; ſuch as their Eclipſes, Tranſits, and Occultations, *&c.* with the accurate Prediction when any of them will come to paſs; which Aſtronomers can now foretel almoſt to a Minute. And the moſt nice and ſubtle Speculation of this Science, is thought to be the Diſappearing of the Sun and Moon; which Phenomena I ſhall here endeavour to explain and account for.

The

The Word *Eclipſe* is deriv'd from the *Greek* ἐκλειπω *(Ecleipo,)* ſignifying to faint, or ſwoon away; ſo ſick, and dying Perſons, when a death-like Faintneſs, or Swooning Fit came upon them, were ſaid by the *Greeks* to fall into an *Eclipſe*. In like manner, the Luminaries ſeem to vaniſh and grow dark when an Interpoſition of the Earth, or of each other, deprives us of their Light; and at ſuch a time the Sun, or Moon, is ſaid to be eclipſed.

The CAUSE is this.

All dark Bodies expos'd to the direct Light of the Sun, caſt a Shadow behind them; which is nothing but the Loſs, or Privation of Light, in the Space oppoſite to the Sun, by reaſon the Sun's Rays are intercepted by the opaque Body: and as the Globes of the Earth, and Moon, are both opaque Bodies, which borrow all their Light from the Sun, when either interpoſes, the other muſt in ſome meaſure be obſcur'd; as the Earth at A, and the Moon in B.

Plate I. Fig. 1.

Hence it appears, that a Solar Eclipſe is cauſed by the Interpoſition of the Moon between the Sun and the Earth; and a Lunar one, by that of the Earth betwixt the Sun and Moon.

Let S repreſent the Sun, D the Earth, M the Moon, and E her Shadow, by which 'tis evident, there can be no Line drawn from

from any Part of the Sun to any Point in the Space I H, upon the Earth's Surface, but will fall upon the Globe of the Moon; and ſince the Moon is a dark Body, it will not ſuffer any Ray to paſs thro' or illuminate the Space I H; therefore that Part of the Earth muſt be depriv'd of the Sun's Light.

N. B. This can never happen but when the Moon is in conjunction with the Sun; for at no other Time her Shadow is caſt upon the Earth.

The Moon being leſs than the Earth, her Shadow can never cover the whole Globe, only a Part of it, ſuch as I H; and total Darkneſs is but to thoſe Inhabitants, on whom the Shadow falls. The circumjacent Places will be illuſtrated with ſome of the Sun's Beams, call'd the * *Penumbra*, (or a lucid partial Shadow;) which will have different Degrees of Illumination, according to the Diſtance from the Center of the real one: without this Penumbra all the Sun's Body will be ſeen at the ſame time, and no Eclipſe perceiv'd at all.

Let S repreſent the Sun in the Equinoctial, and E the Earth; then will A be the Moon conjoin'd with the Sun, to the South Pole; B a true Conjunction at the Earth's Center, Fig. 2.

* The Inhabitants here will only ſee a part of the Solar Diſk obſcure, which will appear to be more or leſs in proportion as they are ſituated nearer or farther remote from the Center.

Center, or in the Equator, and C the Moon conjoin'd with the Sun at the North Pole.

Now 'tis manifeſt, when the Moon is at B, her Shadow falls in the Torrid Zone; and conſequently, muſt take away the Sun's Light from that Part of the Globe; when, at the ſame time, to the North and South Poles, only part of the Sun's Body will be darkned: and when the Moon is centrally conjoin'd at C, the Sun may be totally eclipſed at the North Pole, when at the ſame time, to the South Part of the World; is free from the leaſt Obſcuration.

Hence the *Penumbral Cone* is determin'd in this Manner.

Fig. 3. Let A repreſent the Sun, E the Moon, D the Earth, C the Moon's opaque Shadow, and A, E, D, a right Line joining the three Centers: draw the Line F G from the ſuperior Limb of the Sun to the Earth's Surface, touching the inferior Limb of the Moon, and the Line H I from the inferior Limb of the Sun, touching the ſuperior Limb of the Moon; and they will interſect each other in the Point K; which Point will be the Vertex, and the Line K N the Axis of the Penumbral Cone. About which, if the Line K G or K I be made to revolve, it will deſcribe the Limits of the Penumbra upon the Earth's Surface, and is here repreſented by the faint Shadow L M.

To

To know how much of the Earth's Surface can be involv'd in this Penumbra.

(FIRST,)

Let us ſuppoſe the * Angle of the Cone (without ſenſible Error) equal to the apparent Diameter of the Sun; then, in the Triangle K, O, E, right-angled at O, is given the Semi-Diameter of the Moon O E, and the Semi-Angle of the Cone O, K, E, to find the Diſtance of the Moon's Center from the Vertex K: which when known, added to the Moon's Diſtance from the Earth, will give the whole Height of the ſaid Cone from the Earth's Center: then in the oblique Triangle D K I, is given the Sides D K, and D I, together with the Angle D K I; hence, will be found the Angle N D I, whoſe Meaſure is the Arch I N, the Semi-Diameter of the Penumbra upon the Earth.

After the ſame manner may be found the Quantity of the Earth involv'd in the real Shadow. But if the apparent Diameter of the Sun exceed that of the Moon, the real Shadow will not reach the Earth †: in this caſe, there may be a central Eclipſe of the Sun, but not a total one.

As

* As demonſtrated by Dr. *Keil* in his Aſtronomical Lectures, p. 116.

† This is call'd an Annular Eclipſe, the Moon's Body appears in the Sun's Diſk, ſurrounded by a bright luminous Circle. Such a one was obſerv'd by *Clavius* at *Rome*, *April* the 9th, 1567; and ſuch another paſſed over the City of *Edinburgh*, on the 18th *Feb.* 1736-7, in the Evening.

As 'tis evident there can be no Eclipſe of the Sun, but when the Moon is in the Change *; ſo there can be no Eclipſe of the Moon but at the time of the Full: and ſince there is a new and a full Moon every Month, it will be proper to give a Reaſon why there is not an Eclipſe at thoſe Times every Month too. If the Moon's Orbit lay in the Plain of the Earth's Orbit, *i. e.* if thoſe two Plains were to coincide in a Plain paſſing through the Sun, there wou'd be a total Eclipſe of the Moon at every Full; and conſequently a central † Eclipſe of the Sun at every Change.

But the Orbs of the Earth and Moon (being placed obliquely, and not both in the ſame Plain) interſect each other in two Points, (call'd Nodes) where the Moon's Orbit is found to be inclined to the Ecliptic in an Angle of about five Degrees: therefore, the Moon may be in ſuch a Poſition from the Nodes, as to paſs the Oppoſition, or Conjunction, either too high or too low to fall into the Earth's Shadow, or to have her Shadow or Penumbra fall upon the Earth. Hence 'tis very poſſible, every full and

* Then only the Moon is in Oppoſition to the Sun, and near the Earth's Shadow.

† This is but very improperly attributed to the Sun, becauſe it is really an Eclipſe of the Earth; for all the time, the Sun retains his own Light without the leaſt Diminution; and only thoſe Inhabitants of the Earth that are under the Shadow of the Moon, or of the Penumbra, are truly eclipſed.

and new Moon may not be Eclips'd. And it will further appear, that no Eclipſe can happen but when the Moon is near one of her Nodes; conſequently, the Quantity of Obſervation depends upon the Diſtance from it: And of both kinds, may be either total, partial, or central.

Let E repreſent the Earth, S S S 3 different Poſitions of the Sun, and M M M M M M M various Places of the Moon in her Orbit; let us now ſuppoſe a Conjunction or an Oppoſition to be made at C, at both which Places the Moon happens to be exactly in the Nodes; conſequently, in either of them there will be a central Eclipſe. Again, let us imagine the true *Syzigie* at D or E, in both thoſe Points the Moon has conſiderable Latitude, and can only produce a partial Eclipſe. Farther, if the Moon be removed to G, or H, there will be no Eclipſe at all. Thus, in any Part of the Moon's Orbit, by knowing the Moon's Diſtance from either Node, the Limits of Eclipſes both Solar and Lunar, may be eaſily determin'd; that of the Sun will be found nearly * 18°, and that of the Moon 12°. Plate II. Fig. 4.

Now from the Horizontal Parallaxes of the Sun and Moon, and their apparent Semi-Diameters, the Poſſibility of a Solar Eclipſe is thus determin'd.

Let

* Hence it is that Eclipſes of the Sun, in general, are more frequent than thoſe of the Moon; although in any particular Place they are much fewer.

Let A repreſent the Sun, B the Earth, and C the Moon; then the Angle H E G will be the apparent Diameter of the Sun, ſeen from the Earth's Center, and Q E R the apparent Diameter of the Moon ſeen from the ſame Place, (conſequently her Shadow:) Hence, L K M will be the Penumbral Cone, limiting the utmoſt Extent of ſuch an Eclipſe, and W Z the Quantity of the Earth's Surface involv'd in the real Shadow at the ſame time. Now to find the apparent Diameter of the Penumbra in the Moon's Orbit, we have given the Points L and M, upon the Earth's Superficies; to which, when the Moon is at C, the Circles X Q and R T will repreſent the Sun's apparent Diſk free from Obſcuration.

Plate III. Fig. 5.

To the Inhabitants at L, the Moon's North Limb will juſt touch the Sun's South one, and may here repreſent the beginning of an Eclipſe; when, at the ſame time, to the People at M, the Moon's upper Limb will juſt go off the Sun's lower, repreſenting to them the End of an Eclipſe.

Thus it appears, that the Diſtance of the two Centers, S and Y, is equal to the apparent Diameter of the Penumbra; wherefore upon F, with the ſum of the Semi-Diameters of the Sun and Moon (equal to the Angle F M Y) deſcribe the Circle S Y P, and it will repreſent the Penumbra in the Moon's Orb.

N. B.

N. B. If in the above Figure, C repreſents the Moon perpendicular to the Equator, and N the North Pole, L will be the North Limit and M the South Limit of the ſaid Eclipſe.

Again, to find the apparent Diameter of the Earth's Diſk in the Moon's Orb, you have given the Horizontal Parallax of the Sun N D E, and E F N the Horizontal Parallax of the Moon: draw the Line I O parallel to D K E, then will the Angles E D N and D N I be equal. Therefore out of the Angle F N O (equal to the Moon's Horizontal Parallax) take the Angle T N O, that of the Sun, and there will remain the Angle E N T equal to the apparent Semi-Diameter of the Earth's Diſk in the Moon's Orb. Hence, upon the Center F, with the Difference of the Horizontal Parallaxes of the Sun and Moon E T, deſcribe the Circle X V T, and it will repreſent the ſame.

The Earth's apparent Diſk viewed from the Sun is always equal to 10// the Sun's Horizontal Parallax.

Euclid l. 1. p. 29.

Now, as was ſaid before, if none of this Penumbra fall within the ſaid Diſk, there can be no Eclipſe: for let E be the Diſk in the Ecliptic, and F the Penumbra in the Moon's Orbit, F ☊ is the Diſtance of the Luminaries from the Node: Here 'tis plain that the Moon's Latitude is greater than the ſum of the Semi-Diameters of the Diſk and Penumbra, and therefore no Eclipſe can happen to that Part of the Moon's Orbit. But if the ſum of the Semi-Diameters of the Diſk and Penumbra be

Fig. 6.

To know when there will be an Eclipſe, and when not.

be greater than the Moon's true Latitude, as at C, then an Eclipſe to ſome Place muſt happen unavoidably: And if the Moon's Latitude be leſs than the Semi-Diameter of the Diſk, as at B, the Eclipſe will be central, and ſomewhere may be total. And farther, if all the Penumbra fall within the Diſk, as at A, the ſame for ſome time may be general.

N. B. In Eclipſes that are partial, the Center of the Penumbra falls without the Diſk.

CHAP.

CHAP. II.

The Geometrical Conſtruction of Solar ECLIPSES *for particular Places of the Earth.*

HOW to repreſent the Path of any Vertex upon the Earth's Diſk, as alſo to divide the ſame (being no more than an Orthographical Projection of the Sphere) have been largely ſhewn by moſt of our Aſtronomical Authors; but, however, not to leave the young Students in the dark, ſuch I mean as may not be perfectly acquainted with Spherical Trigonometry, I ſhall in the firſt place exhibit the Manner of doing it here.

LEMMA.

I. To an Obſerver in the Sun, the Earth's enlighten'd Hemiſphere would appear a ſuperficial Diſk: to him, the ſeveral Parts of Land and Water would directly appear as if projected on a Plain; conſequently, if circular Lines, ſuch as the Meridians, Parallels, *&c.* were drawn or imagin'd upon it, there may be conceiv'd an Orthographical Projection of the Sphere.

II. Every Place upon the Earth's Surface, to the Eye as above, in each diurnal Revo-

lution, apparently deſcribes an Elliptical Path, (or otherwiſe a right Line) parallel to the Equator; the Axis of which, at different times of the Year, is variouſly inclined to the Right, or to the Left, from the Axis of the Ecliptic; *i. e.*

III. During the Sun's Progreſs thro' the Summer and Autumn Signs, *(viz.)* ♋, ♌, ♍, ♎, ♏, and ♐, the Axis of the Earth projected on the above Plain, lies to the Left of the Axis of the Zodiack: but if the Sun be in any of the other oppoſite Signs, it will on the contrary be thrown to the Right. If the Sun's Place be in any of the North Signs, *i. e.* ♈, ♉, ♊, *&c.* the North Pole will be enlighten'd; but if otherwiſe (to the South) 'twill be obſure.

COROLLARY.

The conjugate Diameter of every Elliptical Path, apparently increaſes, and decreaſes, as the Sun's Declination doth increaſe or decreaſe. If the Sun is in the Equinoctial, the Path of each Vertex will then be a Right Line, but at all other times orbicular.

N. B. The tranſverſe Diameter of the Ellipſis, repreſenting the Path of any Place, is always equal to twice the Sine Complement of the reſpective Latitude; and the conjugate one, to the Difference of the Sines, betwixt

betwixt the Sum and Difference of the two Complements, Latitude, and Sun's Declination.

PROB. I.

To repreſent the Path, or Way of any Vertex on the Earth's Diſk, as view'd from the Sun.

The General RULE.

Having drawn a Circle as A, B, C, D, let it be ſuppoſed to be the Earth's enlightned Diſk; then by two Right Lines paſſing thro' the Center, croſs it at Right Angles: ſo will one of them repreſent a Part of the Ecliptic, as E F, the other its Axis, as G H. ⊙ is the Vertex Point, or where the Sun is in the Zenith, and B and D the Ecliptic Poles in the Solar Horizon. Plate IV. Fig. 7.

Now as the Obliquity of the Ecliptic is nearly 23° : 30′, ſet this Diſtance from B, both ways, to I and K, then draw the Line I K, and ſomewhere in it you'll find the elevated Pole thus.

Make half this Line, *(viz.)* I L, equal to the Radius of a Line of Sines, and upon it ſet off the Sine of the Sun's Diſtance from the ſolſtitial Colures (which is here repreſented by the Axis B B) from L, towards I or K, according to what Quarter of the Ecliptic the Sun is in; that is to ſay, if the Sun's Longitude be given in ♑, ♒, ♓, ♈, ♉, or ♊, the ſaid Diſtance will be from L towards

K; but if in any of the others, from L towards I. Thus let the Sun be ſuppoſed in the beginning of *Taurus*, or at the end of *Aquarius*, the Pole will be found at P: if in the former, 'twill be viſible; if in the latter, inviſible, being then remote and obſcure: thro' which and the Center of the Diſk, if you draw the Line M N, 'twill repreſent the Axis of the World: and in this caſe P will be the North Pole.

N. B. When the South Pole is elevated, it may eaſily be conceiv'd, (every Plain lying in oppoſition) that the above Rule will be reverſed.

Again, to delineate the Ellipſis which any given Place upon the Earth deſcribes in 24 Hours; if in North Latitude, and the Sun be in

* Northern
† Southern
} Signs, the { Difference / Sum

of the Sun's Declination and the Pole's Elevation will be the diurnal Interſection, or the Sign of the Sun's Meridional Diſtance that Day — from the Path of the ſaid Place, and for the Nocturnal Interſection of the ſame, the direct contrary; *i. e.* if their Sun be that, their Difference will be this.

* or the Latitude and Declination of the ſame kind.
† the ſame of different kind.

Thus, ſuppoſe I would repreſent the Path of *London* in the foregoing Figure, the Sun then being in the laſt Scruple of *Aries*, or at

at the beginning of *Taurus*; his Declination at that time will be 11° : 30′ North; this added to, and ſubſtracted from the Latitude 51° : 32′ North, the ſum is 63° : 2′, and the Difference 40° : 2′.

Make the Semi-Diameter of the Diſk, the Radius of a Line of Sines from which take thoſe two laſt Numbers ſeparately, and place them upon the Axis from the Center, ⊙ towards the Pole * P, the former (12) will be the Nocturnal Interſection of the Arch and Meridian; the latter XII, the viſible one, or that of the Day. Again, biſect that Part of the Axis 12 : XII at Right Angles in R, and on this Line place the Sine Complement of Latitude both ways, from R to VI and 6; thus will be had the extreme Points of each Diameter, thro' which the Ellipſis or Curve is to paſs. Now to determine a ſufficient Number of other Points, in order to be as near the Truth as poſſible in protracting the ſaid Ellipſis, make R 6, and R XII, each the Radius of a different Line of Sines: then, if from the firſt, you take the Sines in Degrees from the Meridian, of ſuch Hours, or Parts of Hours, as is requir'd to be ſhewn in the Path, and place them ſeverally in the ſame tranſverſe Diameter both ways, from R towards the Horizon, and from the Points ſo made, erect as many Perpendiculars, ſuch as 20′, 5°, 40ʰ, 40′, 10°, 20′, 1ʰ, 15°, 11′, *&c.* equal to the Co-Sine

* which if illuminated.

of the ſaid Arches, to each reſpectively taken from the other, or ſecond Scale, you will have 24 Points, or Hours, with other Subdiviſions, repreſenting the true Way and exact Place of the ſaid Vertex, at any time of the Day or Night.

In like manner may be projected the Parallel of the ſame Place at any other time, and of various Places at the ſame time, *&c.*

To illuſtrate which, take the two following EXAMPLES:

Fig. 8. Firſt, Of *London* in *January*, the Sun being in 30° of ♑.

Fig. 9. Secondly, Of *Rome*, at the Summer Solſtice.

N. B. Thoſe two Points where the Path cuts the Limb of the Diſk, are the Places to which the Sun appears to riſe and ſet: to find which more exactly, if requir'd;

Fig. 9. Lay the Latitude of the Place on the Periphery of the Diſk from A to B; from B draw a Parallel to the Diameter, as B C; that done, ſet off the Sun's Declination from E to D, and draw the Line S D. Then will the Diſtance from S, the Center of the Diſk to F the Interſection, applied on the Axis from S, gives you a Point as T; thro' which, if a Line be drawn at Right Angles to the Meridian,

Meridian, it will cut the Circumference in G and H, the Points requir'd.

PROB. II.

To Conſtruct the Appearance of a Solar Eclipſe to any particular Place, &c.

Before we can come at the Geometrical Solution of this Problem, we ought to be well acquainted with the general Calculation; at leaſt to be Maſters of the following Particulars, *(viz.)*

I. The middle Time of the Eclipſe, or of the neareſt Approach of the two Centers; *i. e.* of the Diſk and Penumbra.

II. The Moon's Latitude, at the true Conjunction, at the ſame time.

III. The Semi-Diameter of the Sun.

IV. ——————— of the Moon.

V. ——————— of the Diſk.

VI. ——————— of the Penumbra.

VII. The Inclination of the Moon's Orbit with the Ecliptic. And

VIII. The hourly Motion of the Moon from the Sun. And

IX. Laſtly, the Sun's Declination.

All

All which, being accurately known from Aſtronomical Tables, [ſee the NOTES below] we may in the next place proceed to repreſent the Moon's Way, or Path of the Penumbra over the Earth, and how to divide the ſame to any given Place.

Plate V. Fig. 10. Having deſcribed the Circle A B C D, as before, to repreſent the Diſk, and upon it the Path of the Place, *&c.* draw a † perpendicular to the Moon's Way thus; from a Line of Chords, equal to the Radius of the Diſk, take the Inclination of the Moon's Orb with the Ecliptic, and lay it on the Perimeter of the Diſk, as from B to E, and draw the Line E Q: ſuch a one will repreſent the Perpendicular requir'd.

Again; from a Scale in proportion to the Diſk, take the Moon's Latitude, and place it on this Line, as from ☉ to H; through H

NOTES. Per *Example.*

* *Anno Dom.* 1715. In the Morning Sun in ♉ 12° 14′ 41″.

* Sun's Eclipſe *April* 21, the

The	1	was	21	42	48	P	M.
	2			44	12	N	D.
	3			15	58		
	4			16	46		
	5			61	30		
	6			32	45		
	7		5	34	52		
	8			35	35		
	9		15	34	12		

† If the Moon's Latitude be either North Deſcending, or South Aſcending, this Line will lie to the Right-Hand of the Ecliptic Pole; but if otherwiſe, *i. e.* North Aſcending, or South Deſcending, to the Left of the ſame.

As

H draw a Line, ſuch as I K, at Right Angles to ☉ E, (now ſuppoſed the Axis of the Moon's Way) and it will repreſent the Path of the Penumbra, or of the Center of the general Eclipſe.

Now to divide the ſaid Path properly to the Time, at any given Place; firſt, fix the Time at or near the middle; according as it happens, by making proportionable Allowance, as the Minutes more or leſs require: then, from that Point, by the hourly Motion of the Moon from the Sun, the Motion of the whole Duration may be divided into Time, which if mark'd reſpectively, will ſhew the Place of the Penumbra in its Paſſage over the Diſk, at every Hour and Minute of the ſaid Continuation.

Thus, according to the hourly Motions of the ☾ from the ☉, ſuppoſing the middle of an Eclipſe, at *London*, to be 42′ paſt 9 o' clock in the Morning, the Path muſt be divided, *&c.* as in the Figure. Plate V.

In

NOTES.

As one Hour of Time is to the hourly Motion in Minutes and Seconds of the Moon from the Sun, ſo is any Number of Minutes in Time to Minutes of Motion: hence by the foregoing Calculation, 60′ 35′ 35″ : 30′ 35″ :: 42′ 18″ : 25′ 6″, which, plac'd in the Path from a to b, gives the Place of the Center (Penumbra) at 22 Hours, or X o' clock. Fig. 10.

In the forementioned Eclipſe, proceeding as above directed, the Points for 11 o' clock and 9, by opening your Compaſs to 35′ : 35″, will be found at C and D. The reſt, as is repreſented in the Scheme, from which you may learn to divide, ſubdivide, and mark the ſame accordingly. Fig. 10.

To

In like manner, if regard be had to the Difference of Meridians, any Path may be divided to different Places.

1. *To determine the apparent Time of the Beginning, Middle, and End of an* ECLIPSE.

Take between your Compaſſes, in proportion to that of the Diſk, the Semi-diameter of the Penumbra; and with one Foot in the Moon's Way, moving it from the Left-hand towards the Right, find ſuch a Point, that the Compaſſes ſo placed, as at e, the other Foot may fall upon the ſame Hour, and Minute, in the Path of any given Vertex, as at g; thus will each Leg point to the Beginning of the Eclipſe, at that Place.

Again, your Compaſſes remaining at the ſame Extent, find another Point in the ſaid Path, on which, if one Foot be plac'd, the other as before may cut the ſame Hour, and Mi-

NOTES.

To determine the Requiſites at *London*. From any Scale of equal Parts = 61′ : 30″ the Radius of the Diſk, take the Extent of 32′ : 45″ the Semi-diameter of the Penumbra; and that Diſtance apply'd from one Path to the other, as is taught above, you'll find both pointing to 8^h : 7′, the Time ſought. Fig. 10.

Likewiſe at the End, upon K and L, there ſhewing the Hour 24′ paſt 10. Again at M and N, the equal Times in a Perpendicular to the Moon's Way, you'll find 9^h : 24′ the greateſt Obſcuration, or the neareſt Approach of the two apparent Centers, (☉ and ☾) upon which, if two Circles be drawn, *i. e.* one upon M = to 13′ : 58″. the Semi-diameter of the Sun; and another upon N = to 16′ : 46″ that of the Moon, from the ſame Scale. Fig. 10.

The

Minute, in the Path of the Place; then will either Point ſhew the End of the Eclipſe.

2. *To find the Middle.*

Apply the one Side of a Square to the Moon's Way; ſo placed, move it backwards, or forwards, until the other Side cut equal Time in each Path; *i. e.* the ſame Hour and Minute in one as in the other; the Time ſo found will be that of the greateſt Obſcuration.

3. *To find the number of* Digits * *eclipſed.*

This is known by deſcribing two Circles upon the two laſt Points, which determin'd the Middle of the Eclipſe, *i. e.* one upon the Place, with the Semi-diameter of the Sun; the other in the Moon's Way, with the Semi-diameter of the Moon. Thus will the Quantity obſcur'd be ſhewn in the Sun's Diameter, cut by the Moon's Limb.

4.

NOTES.

The latter will cut off from the former juſt ſo much as the viſible Obſcuration will be. In this manner you'll find the preceeding Eclipſe at *London* will be total, and exactly 12 Digits.

N. B. The Air happening to be very clear when this Eclipſe was obſerv'd, ſeveral of the Planets and fix'd Stars during the time of total Darkneſs, became viſible to the naked Eye.

* A *Digit* is the twelfth Part of the Sun's Diameter.

4. *How to project the visible Appearance of the* ECLIPSE.

Let M represent the Sun, and N the Moon, at the middle of the Eclipse, draw the Line ⊙ M V, as also M N, then will ⊙ V represent the Vertic Circle, and V M N the Angle of Obliquity, as made by the Line of Connection M N. Consequently O, being the Vertic Point of the Sun's Limb, if the said Lines be revers'd, as in the Figure, the Position of the visible Eclipse, with respect to a Perpendicular passing thro' the Sun, may be naturally shewn, not only at the Middle, but if required at both the Beginning and End.

Fig. 11.

In Eclipses that continue for some time total, or annular, if instead of the sum of the Semi-Penumbra of the Sun and Moon, you make use of their Difference, *i. e.* instead of the Penumbra for total Darkness make use of the Umbra, you may easily find the Beginning and End of the same.

N. B. The Way of the Moon's Shadow, *&c.* over *England* in this Eclipse, was, as is represented in Plate XII.

PROB.

PROB. III.

To find, at any Time, and in any part of the Path upon the Earth's Surface, the Species of the total Shadow, or of the annular Section of the Penumbra.

The General RULE.

Upon the Center-Point, as at A, deſcribe a Circle equal to the Difference betwixt the apparent Diameter of the Sun, and Moon; this Circle ſhall project upon the Globe the true Quantity of the ſaid Shadow, or Penumbral Section; therefore, if you take the Dimenſion of it from a Scale of Sines, in proportion to the Radius of the Diſk, and transfer it upon a Plane, you will have the true Poſition, Figure, and Direction upon the Earth; which in all Parts of the World, but where the Sun is Vertical, will be an Ellipſis, and more or leſs irregular, according to its Diſtance from the Solar Horizon *. Pla. VI.

The Obliquity of this Figure intirely depends upon the Sun's Altitude; and in Eclipſes that happen near the Horizon, is very much diſtorted during its Stay on the illuminated Hemiſphere; upon every different Country, it is continually changing its Shape, and putting on a new Form, ſuch as A, B or C. Plate VII.

N. B.

* The Direction of the Middle is various, according to the Seaſons of the Year, and Time of the Day.

N. B. The Section of every Cone, *&c.* made by a ſpherical Surface, is not eaſily determin'd any other way but by Conſtruction; in the vaſt Penumbra it is beſt underſtood by throwing a diſtinct Shadow upon a round Ball or Globe.

The longer or tranſverſe Diameter always coincides with the Line of the Sun's Azimuth; the Conjugate is at Right Angles to it.

Let E be the Earth's Diſk, A the Moon's Center in the Line of her Paſſage over it, N O, and the Circle B C D F the Space or Portion of the Earth's Surface to be delineated. Draw the Diameter G A H, and at Plate VI. Right Angles to this, the Line I K paſſing thro' the Center of the Penumbra: alſo a Perpendicular to the Path, as L M. Now if to theſe be drawn other Lines parallel, ſuch as a b, c d, e f, g h, i k, l m, n o, and p q equal to the Radius A B; then will a n c, f m h, and i m be the true Dimenſions of the ſaid Shadow, or Penumbra, in all its parts from the Center, *i. e.* i m will be the ſhorteſt

NOTES.

That narrow Compaſs call'd the Umbra, or the ſmall Annular Space of the Penumbra, approaches nearly to a Plane; being the Section of a Cone cut by a Spherical Surface; whence it will appear (*Euclid*'s Elements L. III. P. 6.) that the proper Center or Axis of the Cone, is not the real Center of the Eclipſe.

The

ſhorteſt Diameter, and o q the longeſt; a c will be the perpendicular Breadth, and f h the Obliquity: Which, if meaſur'd in Degrees, and reduced into Geographical Miles, you may eaſily know both its Limits and Direction.

Thus, it was found, in the great Annular Eclipſe of the Sun, *Anno* $173\frac{6}{7}$, that the Moon's Penumbra was thrown upon the the Earth, to us in *Europe*, as is repreſented * in Plate VII, at C. Plate VII.

SCHOLIA.

The Duration of total Darkneſs, and conſequently the Extent of the Umbra, Penumbra, or intire Eclipſe to different Places, along or near the Path of the Moon's Center, is vaſtly various, upon account of the unequal Elevation of the Luminaries above the Horizon; for the Moon is much nearer to the Earth when ſhe is in the Meridian than when ſhe is riſing or ſetting; and in Con-

The Moon is nearer to the Earth when in the Zenith of any Place, by a ſixtieth part of her Diſtance from us, than when ſhe is in the Rational Horizon.

* See the geometrical Conſtruction of that Eclipſe, printed for Mr. *Senex*.

NOTES.

The Duration of the Solar Eclipſes in any particular Place, is more or leſs according as they happen nearer to or farther from Noon; by reaſon, near 6 o'clock, the diurnal Motion conſpires with the Ecliptic one leſs than at 12 o'clock at Noon.

The Velocity of the Shadow is very unequal; ariſing not only from the Inequality of the Moon's own proper Motion, but alſo from the oblique Variation of every Horizon; but

Conjunctions, which happen near the Zenith, this is very conſiderable; therefore in order to obtain a diſtinct Knowledge of the ſame, and the accurate Determinations of them, a particular Allowance muſt be made.

Of the general Tranſit of an ECLIPSE, &c. *and how to find the Time and particular Place of the Beginning,* &c, *of the general* ECLIPSE.

Let BRCN repreſent the Earth's Diſk in the Ecliptic, BC and FK, *&c.* the Moon's Way or Paſſage of the Penumbra over it; P the North Pole. Now, the Time when the Plate VIII. Moon's Center will be at F D I H M E and R, is requir'd. In the firſt place here is given F O = to K O, the Sum of the Semi-diameters of the Diſk, and Penumbra; ſecondly, D O = O E, the Semi-diameter of the Diſk; and laſtly, M O, the neareſt Approach of the Luminaries to the Center of the Diſk, to find F O H, and D O H, the two Angles of Incidence. By the Solution of a Right-angled Triangle, (having found the Reduction M H) ſay, As O P or D O is to Radius, ſo is H O to the Sine Complement of the Angle H O F, or D O H: Then

NOTES.

as the Latitude and the Longitude of any Point, in its Direction, may be eaſily known, there can be no great Difficulty in finding it.

Then to find the Semi-duration F H, or H K; the Analogy is, as Radius, is to F O: ſo is the Angle of Incidence F O H, to F H. * In like manner may be found D H = to H E, which, if divided by the hourly Motion of the Moon from the Sun, will give each reſpective Arch in Time; this added to, or ſubſtracted from the Time of the greateſt Obſcuration, will give the Beginning and End of the general Eclipſe, *&c.*

Now to find the Latitude and Longitude of thoſe Places upon the Earth, over which the Center of the Penumbra paſſes; ⊙ will be that place to which the Sun is Vertical; its Latitude is always equal to the Sun's Declination, and its Longitude, from the Place to which the Tables are accommodated, is equal to the Time from Noon in that Place reduced into Degrees and Minutes. Hence the Poſition of the Center is known, and conſequently, by the Doctrine of Spherics, the Latitude and Longitude of any given Point, ſuch as G, D, I, H, M, E, or L, may be found †.

* Or per *Euclid* I. and 47.
$FH = \sqrt{\square FO - \square HO}$.

† G is the Place where the Shadow firſt touch'd the Earth.
D the Place where the Center comes on.
I the Point where the Sun is eclipſed in the Univerſal Meridian.
H the Place where the Center falls.
M the Nonageſimal Degree.
E the Place where the Center goes off from the Earth.
L the Place where the Penumbra leaves it.

The mean Velocity of the Shadow over the Earth, is always equal to the hourly Motion of the Moon from the Sun, in the Moon's Orbit reduc'd into geographical Miles.

Hitherto has been explain'd and demonſtrated the general Cauſe and Phenomenon of a Solar ECLIPSE: I ſhall in the next place procced to the Geometrical Conſtruction of the ſame, in a more particular Manner. But firſt, 'twill be proper, as preparatory to it, to give an Epitome of the Calculation.

CHAP.

CHAP III.

A Calculation *of the* SUN's ECILPSE, *in* May 1733.

MEAN Motion of the ☾ *a* ☉, at the Beginning of *May*	S	°	′ ″
	11 :	2 :	55 : 5
Diſtance of the ☾ *a* ☉		27 :	4 : 55
Hence, dividing by the daily Motion of the ☾ *a* ☉, the mean Conjunction will be *May* 2d	h	′	″
	5 :	19 :	0 p.m.
Interval of the Mean, and true Sub.		6 :	52
Equal Time of the true ☌, 2d	5 :	12 :	8

At

NOTES.

In this Eclipſe the Moon's Penumbra firſt enter'd the Diſk in the great South Sea, or unknown Weſtern Ocean, 280 Leagues Weſt of *California*, and 300 Leagues to the South Weſt of New *Albion*; there the Eclipſe begun at Sun-Riſe (the Moon's lower Limb juſt touching the Sun's upper one) in the viſible Horizon. From thence, gradually increaſing, it ſpread it ſelf over the Kingdom of *Mexico*, *Florida*, and the *Caribbee Iſles*. The Inhabitants of which beholding more or leſs of the Sun's Body obſcure, according as they were ſituated at that time nearer or farther remote from the Umbra, (or total Shadow;) which ſoon after came upon the Globe, in the ſame Great Ocean: To the Weſt of *America*, betwixt *Japan* and *California*, 480 Leagues Weſt of Cape *Sebaſtian*, and 400 Leagues Eaſt of *Terra-de-Jeſſo*, the Sun was

Latitude 28° : 12′.
Longitude 148° : 50′.
Latitude 45° : 40′.
Longitude 170° : 19′.

	S	°	′	″
At which time, the mean Anomaly of the Earth, is	10	13	42	57
——— of the Moon,	6	19	5	53
Place of the Sun in ♉,		22	51	47
Excentric Place of the ☾, ♉,		22	51	47
Node Ascending in ♐,		1	53	22
Argument Latitude,	5	20	58	25
Reduction add			2	11
Moon's Place in the Ecliptic, ♉,		22	53	58
Her Latitude N. Descending,			47	0
Hourly Motion of the Moon,			37	55
——— of the Sun,			2	24
Of the Moon from the Sun,			35	31
Hence the Time of Reduction Sub.			3	41
Ergo, the true Ecliptic Conjunction is,	2d	5	8	27
Equation of Time, add			6	41
Apparent Time of the true Ecliptic Conjunction *May* 2d		5	15	8

The

NOTES.

* Latitude 76°: 0′. Longitude 112°: 24′. † Latitude 88°: 44′. Longitude 111°: 12′. Latitude 62°: 48′. Longitude 20°: 10′ E.

was seen to rise totally and centrally eclipsed; the Center Point shaping its way North-eastward, and after having travell'd above 800 Leagues over the vast invisible Continent of North *America*; at length, arriv'd at *Baffin*'s Bay, in different Parts of which the * Center of the Penumbra fell at the Middle; the † Sun was totally eclips'd in the Meridian and in the Nonagesimal Degree.

Thence continuing its Course Eastward, the central Shadow in a curvilinear Path, bending over the Artick Circle, upon the Borders of the Frigid Zone, directing its way over *Greenland*, North of *Iceland*, and overtook *Europe* by *Drontheme* in *Norway*: Then in the Oriental Parts of *Sweden*,

100

	h	′	″
The Sun's Declination is	18	32	10
Semi-diameter of the Sun		16	7
——————— of the Moon		16	43
Together is the apparent Semi-diameter of the Penumbra		32	50
Horizontal Parallax of the ☉,			10
——————————— of the ☾,		58	29
Their Difference equal to the apparent Semi-diameter of the Earth's Disk in the ☾'s Orbit		58	19
Inclination of the ☾'s Way,	5	33	30

Hence it appears by the Calculation there will be an Eclipse; and operating by the foregoing Rules, the general Transit will be as follows:

		h	′	″	
Time 10, *London* in the Evening, visible Conjunction at the Earth's Center, or Time of the Nonagesimal central Eclipse		5	15	8	p.m.
Excentricity, equal to twice the Reduction,	add,		7	22	
					Middle

NOTES.

100 Leagues South of *Lapland*, and 240 Miles North-East of *Stockholm*, the Penumbral Center went off from the Earth.

To the Inhabitants there, the Sun appear'd totally obscure in the Horizon; (the same as in the Morning to *America*.) Lastly, in the Bay of *Biscay*, one hundred Leagues South-west of *Paris*, and forty Leagues North of the Coast of *Spain*, having over-run all *Moscovia* and some Parts

Latitude 44°: 50′.
Longitude of 6°: 18′. W.

	h ′ ″
Middle Obſcuration, or the neareſt Approach of Centers	5 : 22 : 30
Semi-central Duration	1 : 6 : 12
Semi-continuance	2 : 17 : 30
The Beginning at	3 : 5 : 0
Beginning Central	4 : 15 : 18
End ditto	6 : 28 : 42
End gen.	40 : 0

The total Duration is 4 hours and 35 Minutes; and at 26′ : 58″ paſt 5, the Sun will be totally and centrally eclips'd, in the univerſal Meridian.

Breadth of the total Shadow 72 Miles.
——— of the Penumbra 4299
Mean Velocity 40 Miles per Minute.

N. B. The total Shadow is here ſuppoſed nearly equal to as many Miles, as the Difference is in Seconds, of the two Diameters ☉ and ☾.

NOTES.

of *Great Tartary*, the Penumbra intirely left the Earth, and the general Eclipſe ended with the ſetting Sun.

This Eclipſe was viſible to all *Europe*, North *America*, Part of *Africa*, and the *Turkiſh* Bounds of *Aſia*; extending from beyond the North Pole over all the *Mediterranean*, and to the Inhabitants of *Poland*, the *Baltick*, and Places adjacent, (*viz.*) *Denmark*, *Germany*, *Great Britain* and *Ireland*; and alſo to thoſe who traverſed the *Atlantic* Ocean.

CHAP.

CHAP. IV.

Of LUNAR ECLIPSES; *particularly of that of* March, 1736.

NOW theſe are occaſion'd by the Interpoſition of the Earth betwixt the Sun and the Moon. For the Moon, being an opaque Body, and only reflecting Light borrow'd from the Sun, is therefore depriv'd of that ſerene Luſtre, by falling into the Earth's Shadow*; and for the ſame Reaſon, as to Quantity and Duration, is both general and univerſal.

Now the Moon, altho' depriv'd of the direct Solar Beams, is not abſolutely hid from us at the ſame time, (as at the Change;) becauſe the Rays of Light paſſing through our Atmoſphere are refracted, and thrown obliquely into the real Shadow, and thereby faintly illuminates their whole Cone. Hence it is, that the Moon's Body remains viſible to us, tho' it be totally Eclipſed.

Let A repreſent the Sun, B the Earth, C the Moon, and K our Atmoſphere; then

H

* A Lunar Eclipſe can never happen but at the Full, and when the Moon is leſs than half a Sign from one of the Nodes. See Page 110.

HFI will be the Cone of the perfect Shadow, HGI the Penumbra, and L the circular Sections cut by a Plain in the Moon's Orbit. Now by the Rays of Light in our Atmosphere, as M and N, the Space EEE becomes lucid; by which Refraction, the Moon is faintly illuminated, and appears to us in a total Eclipse, and visible according to the Quality of the Atmosphere.

Plate IX. Fig. 1.

Of Lunar Eclipses there are four Sorts, viz.

1. Total, and Central.
2. Total, (not Central) with Continuance.
3. Total, without Continuance; and
4. Partial.

The First, is when the Moon passes thro' the Center of the Shadow; such a one is represented by the Diagram A. The Second, is when the Moon becomes totally eclipsed, and continues so for some time before she receives any Light, as at B. The Third, is when the Moon no sooner becomes totally obscure but she that moment begins to recover Light, as at C. The Last, is when only a part of the Moon's Body is involv'd, as appears at D.

Plate IX.

The Beginning and End, *&c.* of a Lunar Eclipse, is found in the same Manner, (by the Angles of Incidence, *&c.*) as was before taught

taught of the Sun's; and needs no further Example*.

To find when there will be an Eclipſe of this kind, and when not.

If at any time the ſum of the Semi-diameters of the Moon and Shadow exceed the Moon's true Latitude, that full Moon will be eclips'd — and if their Difference be more than the ſaid Latitude, it will be total.

An Epitome of the CALCULATION.

Given Time, *viz.*

In *March*, 1736.

	S	°	′	″
Middle Motion of the Moon from the Sun at the Beginning of *March*	11	8	9	4
Diſtance of the Moon from the Sun at that time,		21	50	56
The Oppoſition of which is	6	21	50	56

Whence by Reduction of the Motion of the Moon from the Sun into Time, the mean Oppoſition will be found, h ′ ″

being *Leap-Year*, *March*	15,	13	22	53
The Interval of the mean and true ☌ ſub.		1	23	13
Hence the equal Time of the true ☌ is	15	11	59	40

At

* Only with this Difference, that whereas in the former it is underſtood of the Diſk and Penumbra, here the ſame is to be underſtood of the Moon and the Earth's Shadow.

	S	°	′	″
At which time the mean Anomaly of the Earth, is	8	26	54	38
——— of the Moon	7	6	4	57
Place of the Sun in	♈,	6	42	6
——of the Moon in her Orbit	♎,	6	42	6
Node Aſcending ☊ in	♎,	6	22	37
Argument Latitude	0	0	19	29
Reduction Sub.				5
Moon's Place in the Ecliptic	♎,	6	42	1
Her Latitude N° Aſcending,			1	42
Hourly Motion of the Moon			37	16
——— of the Sun			2	28
Of the Moon from the Sun			34	48
By which divide the Reduction gives the Time to be added				9
Ergo, the equal Time correct is	h	′	″	
	11	59	49	p. m.
* Then for the horizontal Parallax of the Moon			′	″
			60	19
ſubſtract the Semi-Angle of the Cone,			13	59
and there will remain the apparent Semi-diameters of the Earth's Shadow, in the Moon's Orb,			46	20
Semi-diameter of the Moon add			16	38

Ag-

* *Demonſt.*) Draw the Line A B parallel to the Axis of the Cone D C, then (per *Euclid* I. 23.) D C A is equal to C A B. Hence, B A C leſs B A E = A E D, is equal E A C, the Angle required. See Plate IX. Fig. 2.

	° ′ ″
Aggregate of the Semi-diameters	62 : 58
Left by the Moon's Latitude, is the Parts deficient,	61 : 16

And as the Moon's Semi-diameter is to ſix Digits, ſo are the Parts deficient to the Digits eclipſed = 22° : 6′ : 10″.

Again the Sum, and Difference of the Semi-diameters of the Moon and Shadow, ſquared, leſs the Square of the Moon's Latitude, is equal to the Square of the Minutes of Incidence, and of half Continuance in the Shadow, (that is) to the Motion of half Duration 62′ : 57″, and to half the Motion of total Darkneſs 29′ : 39″; which divided by the hourly Motion of the Moon from the Shadow, gives the

	h ′ ″
Time of the firſt,	1 : 48 : 32
—— of the laſt,	51 : 8
Excentricity, or Diſtance of the true Oppoſition, and the greateſt Obſcuration,	8
Time ditto, ſub.	14
Equation of Time, ſubſtract	1 : 55

	S ° ′ ″
Motion of the Moon's Latitude at the Beginning,	11 : 29 : 12 : 5
At the End	0 : 1 : 26 : 53
Latitude at the Beginning S. D.	4 : 10
—— at the End N. A.	7 : 34

Hence

Hence the visible Phenomena at *London* will be as follows.

Plate IX. Fig. 3.

		h	′	″	
A	the Beginning,	X	9	8	Evening.
B	Beginning total,	XI	6	32	Evening.
C	Middle,	XI	57	40	Evening.
C	Opposition,	XI	57	54	Evening.
D	End total,	XII	48	48	Morning
E	End,	I	46	12	Morning

Time of total Darkness, $1^h : 42' : 16''$.
——— total Duration, 3 : 37 : 4. *

This very conspicuous Opposition, in which was naturally exhibited all the Variety of Obscuration, was made near the Moon's Perigeon; being as great almost, as could possibly happen.

It was observ'd in every respect by good Instruments, and several of the ablest Astronomers, and found to be exactly consentaneous to this Calculation, made and publish'd by the Author: which is a great Confirmation of the Truth of the present Lunar Theory near the Syzygies.

* The Colour of the Moon in this Eclipse, according to the Doctrine of *Alphonsus*, should have been a pitch Black, mix'd with Red and Greenness; but was observ'd to be a Misty Black, mix'd with Redness: so that this part of the Doctrine is not to be depended upon.

CHAP.

CHAP. V.

Of Tranſits, Occultations, &c.

A *Tranſit* is the Paſſage of an inferior Planet, over the Sun's Diſk; ſuch as E and D. Pla. IX.

Let A repreſent the Sun in the Ecliptic Way, B C and D E, E F or F G the Primary Orbs of *Venus*, or *Mercury*; then, to an Obſerver on the Earth, H will be a Conjunction, or viſible Tranſit of either of thoſe Planets, with Latitude Aſcending; and K a Tranſit of either Deſcending: at I is repreſented a central one in the Node; the Immerſion of which is ſuppoſed at P, and its End at Q. Fig. 4. Fig. 5.

An *Occultation* is the diſappearing of a Planet, or Star, when conjoin'd with the Moon in a Space oppoſite to the Eye. The Moon paſſing betwixt us and them, ſeems to cover them, by which means, they are for ſome time hid from our Sight.

Let A repreſent the Moon, I or H a Star, or Planet; it now appears that all the while any Body is in the Space B C D, or in the Section Q, it will paſs behind the Moon, and be inviſible: Such is the Repreſentation at X. Fig. 6.

To

To thoſe who are perfectly acquainted with the Calculation, or Conſtruction of Solar and Lunar Eclipſes, there can be no new Difficulty in underſtanding the Solution of theſe; therefore I ſhall proceed no farther on this Head.

I have nothing more to add, but, by way of Example, two intire Calculations of the Sun's Eclipſe; one in *May* 1733, calculated for the City of *Durham*, (paſt;) the other in *July* 1748, for *London*, (to come.) Both which I hope will not be unacceptable to the Curious; eſpecially to thoſe who are willing to compare the Method of conſtructing one geometrically, with that depending upon the Doctrine of Parallaxes.

CHAP.

CHAP. VI.

A Calculation *of a* SOLAR ECLIPSE, *made* Anno 1724, *from* Aſtronomia Carolina.

THE apparent Time of the true Conjunction of the Sun and Moon to the City of *Durham*, h ′ ″

Anno 1733, was *May* the 2d	5 : 9 : 36 p.m.
At which Time	
Is found Right Aſcenſion of the Sun	☉ 50 : 27
——————— in Time	77 : 24
Together is the Right Aſcenſion of the Mid-heaven	127 : 51
Its place in the Ecliptic	♌ 5 : 28
Inclination, Ecliptic and Meridian	75 : 49
Declination of the Point N°	18 : 58
Altitude of the Equation	35 : 10
Sum is the Altitude of the *M. C.* at *Durham*	54 : 8

Then to find the Diſtance of the Nonageſima Degree from the *M C*, the Analogy is

As RADIUS

Is to the Sine Compliment of the Meridian Angle, ſo is the Tang. Complement of the *M. C.* Altitude to the Tang. of its Diſtance from the Nonageſima Degree.

	° ′
Which is hereby found Oriental	10 : 3
Hence the Nonageſima Degree is in ♋ occidental	25 : 25
Diſtance from the Sun, Eaſt	62 : 34
Sun's Declination N°	18 : 32
Of the Moon North	19 : 17
☾'s Diſtance from *M. C.*	77 : 34

Hence by Solution of a ſpherical Triangle will be found

Altitude of the Sun	22 : 16
—— of the Moon	22 : 47

	′ ″
Parallax of the Sun	0 : 7
—— of the Moon	54 : 25
Of the ☾ *a* ☉ in Circle of Altitude	54 : 18

Then to find the Parallactical Angle, or the Angle made by a Vertic Circle paſſing thro' the Sun, with the Ecliptic: Say,

As RADIUS,

Is to the Tang. of ☉'s Diſtance a Nonageſima Degree, ſo is the Tang. of the ☉'s Altitude to the Sine Comp. requir'd.

Hence the Angle ſought is ° ′ 37 : 56

Then for the Parallax of the Moon, from the Sun, that is her Longitude: Say,

As RADIUS,

Is to the Tang. of the ☾ *a* ☉ in Altitude: So is the S C° of the Parallactical Angle, to the Tang. of the ☾ *a* ☉ in Longitude.

Hence it will be found ′ ″ 42 : 53

This

This is the viſible Diſtance of the Moon from the Sun in Longitude, at the true Conjunction: which is more than her true hourly Motion.

Hence the viſible Conjunction will ſucceed the true above an Hour, by reaſon the Moon at *Durham*, viſibly wants of the Sun's Place.

Therefore to an Hour ſucceeding the true, h ′ ″

viz. 6: 9:36

Working by the foregoing Method will be found, ° ′

Place of the Sun in ♉	22: 54
—— of the Moon in ♉	23: 32
Moon's Latitude N°	44
Right Aſcenſion of the Sun	50: 29
—————— of the Moon	50: 57
—————— of the *M. C.*	92: 24
—————— in Time	142: 53
Diſtance of the ☉ from the *M. C.*	91: 56
M. C. in the Ecliptic ♌	20: 28
Angle of Inclination	71: 26
Declination of the Point	14: 43 N°
Its Altitude at *Durham*	49: 59
Diſtance from the 90° E.	15: 1
Nonageſima Degree in ♐	5: 27
Diſtance from the Sun Eaſtward	72: 33
Declination of the Sun	18: 33
—————— of the Moon	19: 24
Altitude of the Sun	13: 44
—— of the Moon	14: 40

	′ ″
Parallax of the Sun	0 : 12
——— of the Moon	56 : 51
Of the Moon from the Sun	56 : 39
Parallactical Angle	38 : 39
Hence the Parallax of the Moon from the Sun, in Longitude, is	44 : 3
Difference of Parallax in the Hour	1 : 10
Which ſubſtract from the true hourly Motion of the Moon from the Sun, gives the viſible Motion to the Hour ſucceeding,	34 : 21

By which divide the apparent Diſtance of the Moon from the Sun, at the true Conjunction; and it gives the Interval in Time, $1^h : 14' : 55''$

Hence the viſible Conjunction of Luminaries at *Durham*, will be *May* 2^d $6^h : 24' : 31''$ p.m.

At which Time	° ′ ″
The Place of the Sun, is in ♉	22 : 54
——— of the Moon in ♉	23 : 41
Moon's Latitude	42 : 54
Right Aſcenſion of the Sun	50 : 29
——— in Time	96 : 7
——— of the *M. C.*	146 : 36
M. C. in the Ecliptic ♌	24 : 17
Angle with the Meridian	70 : 32
Declination of the Point	13 : 28
Its Altitude	48 : 38
Diſtance from the 9° E.	16 : 21

Nona-

	°	′	
Nonageſima Degree in ♌	7	56	
Sun's Diſtance from it	75	2	W.
Angle with the Vertic Circle	39	32	
Declination of the Sun	18	33	
——————of the Moon	19	27	
Her Diſtance from the *M. C.*	95	31	
Altitude of the Sun	11	39	
—— of the Moon	12	43	″
Hence the Parallax of the ☉ is		0	13
——————————of the ☾ is		57	19
Of the Moon from the Sun		57	6
Of the Moon from the Sun in Longitude,		44	3
In Latitude		36	21
Which ſubſtract from the Moon's true Latitude; gives the viſible Latitude, North Deſcending		6	33
The apparent Semi-diameter of the ☉ is		16	7
——————————of the ☾		16	43
Their Sum is		32	50

From which ſubſtract the viſible Latitude of the Moon, and there will remain Parts deficient 26 : 17

Then for the Quantity of Obſcuration.

As the Diameter of the Sun,
Is to 12 Digits:
So are the Parts deficient
To the Digits Eclipſed.

	°	′	″
Which is here found	9	47	2

Then for the Scruples of Incidence: To the Logiſtical Log. of the Moon's viſible Latitude, add the Logiſt. Log. of the Sum of the Semi-diameters ☉ *a* ☾, and the Sum will be a Sine, the Co-Sine of which add to the Logiſt. Log. of the Sum of the ſaid Semi-diameter, and the Sum leſs 10.0000, will be the Logiſtical Log. of the Scruples required.

	′	″
Hence the Motion of half Duration is	32	11

Then to know the Beginning and End of the Eclipſe, we muſt have the viſible hourly Motion of the Moon, from the Sun, both at the Immerſion and Emerſion; therefore to an Hour preceeding, *viz.* $5^h : 24' : 31''$

	°	′
The Place of the Sun is in ♉	22	52
——— of the Moon in ♉	23	3
☾'s Latitude N° Deſcending		40
Right Aſcenſion of the Sun	50	27
——— in Time	81	7
——— of the *M. C.*	131	34
M. C. in the Ecliptic ♌	9	8
Angle with the Meridian	74	38
Declination of the Point N°	18	2
Its Altitude	53	12
Diſtance from the 90° E.	11	13
Nonageſima Degree in ♑	27	55
Sun's Diſtance from it	65	3 W.
Declination of the Sun	18	32
——— of the Moon	19	14

Moon's

	°	′	″
Moon's Diſtance from *M. C.*	81	6	
Altitude of the Sun	20	7	
——— of the Moon	20	41	
Parallax of the Sun		0	8
——— of the Moon		55	2
Of the Moon from the Sun		54	54
Angle of Parallax		38	4
Parallax of the Moon from the Sun in Longitude		43	13
In Latitude		33	51
Difference of Parallax in Longitude for the Hour			50

Which ſubſtract from the true hourly Motion of the Moon, from the Sun, at the Middle, and there will remain 34′: 41″, the viſible hourly Motion to the Hour preceeding: by which divide the Scruples of Incidence, and the

	′	″
Time will be found	55	41

Again, to an Hour ſucceeding the true, (*viz.*) p. m. 7^h: 24′: 31″

	°	′
The Place of the Sun ♉	22	56
——— of the Moon ♉	24	19
Latitude of the Moon		46
Right Aſcenſion of the Sun	50	31
——— in Time	111	7
——— of the *M. C.*	161	38
M. C. in the Ecliptic ♏	10	6
Meridian Angle	67	44
Declination of the Point	7	49
Altitude of it	42	59

	° ′
Distance from the 90°	22: 8E.
Nonagesima Degree ♌	17: 58
Sun's Distance from it	85: 2W.
Declination of the Sun	18: 34
——— of the Moon	19: 39
Distance of the ☾ from the *M. C.*	109: 54
	° ′ ″
Her Altitude	5: 11
Altitude of the Sun	3: 38
Parallax of the Sun	0: 15
——— of the Moon	58: 22
Of the Moon from the Sun	58: 7
Vertical Angle	43: 3
Parallax of the Moon from the Sun in Longitude	42: 28
——— in Latitude	39: 41
Difference of Longitude in the Hour	1: 35
Which added to the true hourly Motion, gives the visible Motion to the Hour succeeding	37: 6
By which, divide the Scruples of Incidence, and it gives the Time of Repletion	52: 3
Lastly, the Moon's Latitude N° Descending, gives the Distance of the visible Conjunction, and the greatest Obscuration	32
In Time, to be added	54

Hence,

Hence, according to this Calculation, the viſible Phenomenon was to have been as follows, and was obſerv'd to be nearly ſo.

Durham, *May* 2d 1733, p. m. or in the Evening.

	H. M. S.
Beginning	5 : 29 : 44
Viſible Conjunction	6 : 24 : 31
Middle	6 : 25 : 25
End	7 : 17 : 28
Total Duration	1 : 47 : 44
Digits Eclipſed	9 : 47 : 10
Viſible Latitude of the Moon at the Beginning	12 : 10
Viſible Latitude of the Moon at the End	0 : 0

To complete this *Calculation* of this ECLIPSE, I ſhall repreſent the Paſſage of the Moon's Body over the Sun's Diſk. See Plate X. Fig. 7.

Let A X Y Z repreſent the Sun's Body, B F D E the Penumbra, B G H the Ecliptic, and B D L K the Lunar Way; then will E A F be a Vertic Circle, paſſing thro' the Sun at the neareſt approach of the two Centers, and N O the Horizontal Line: D will be the Moon's Poſition at the Beginning, L her Poſition at the Middle, and B the End, exactly in the Node; as K is the true Con- Fig. 7.

Conjunction, and X Y Z the Quantity of the Sun's Body obſcured, hence it appears, that the North Part of the Sun's Diſk will be darken'd, and only $\frac{1}{11}$ of his Light left ſhining to the South.

CHAP.

CHAP. VII.

Of the SUN's ECLIPSE *in* July 1748. *Originally Calculated from Sir* ISAAC NEWTON's Theory. ——— *To the City of* LONDON.

		S o ′ ″
July 14th 1748. A M —	Sun in ♌	4: 2:42:37
	Mean Anomaly	0:24:56:10
	Apogee	3: 8:34:25
	Ecliptic Equation	— 0:47:58
	Right Aſcenſion	125: 0: 0
	Declination	19:35: 0

Of the Moon.	Longitude.	Apogee.	Node.
	S o ′ ″	S o ′ ″	S o ′ ″
Anno. 1748.	2: 1:21:20	3: 0:46: 5	10:18:22:37
July —— B —— 13	1:19:23:49	21:43:28	10:19:35
Hours —— 23	12:37:39	6:24	3: 3
Minutes —— 26	14:16	: 7	3
Mean Motions ——	4: 3:37: 4	3:22:36: 4	—. 10:22:41
Firſt Equation ——	+ 4:52	—. 8:15	10: 7:59:56
			+. 3:55
☾ firſt equated ——	4: 3:41:56	3:22:27:49	10: 8: 3:51
Second Equation ——	—. 1:16	+. 3:33:32	—. 16:15
☾ ſecond equated ——	4: 3:40:40	3:26: 1:21	10: 7:47:36
Third Equation ——	+ 9		
☾ third equated ——	4: 3:40:49		
Apogee, laſt equat. —	3:26: 1:21		
Mean Anomaly ——	0: 7:39:28		
Ecliptic Equation ——	—. 0:56:54		
True Anomaly ——	0: 6:42:34		
Apogee, laſt equat. +	3:26: 1:21		
☾ fourth equated ——	4: 2:43:55		
Fifth Equation — +	3		
☾ fifth equated ——	4: 2:43:58		
Sixth Equation — +	44		
☾ in her Orbit ——	4: 2:44:42		
☉ in the Ecliptic —	4: 2:42:37		
Diff. of Longitude —	2: 5		

Excentricity -	66166.
Logarithm —	9,942446.
Hourly Motion ☾	29′: 26″
—— of the ☉	2: 23
Hour Motion ☾ *a* ☉	27: 3
☾'s horizontal Parallax	53: 58
Inclination Limit	° 17: 39
Angle of the ☾'s Way	5:45: 0
As Hor. M. ☾ *a* ☉	27′: 3″. 3460
Is to one Hour	60 :0. ——
So is diff. Longitu.	2: 5,14594
To diff. in Time	4:37,11134

Hence

		D.	H.	M.	S.
Anno 1748. *July* —	Hence the true Orbit Conjunction —	13	23	21	23
	Sun's Place and ☾ in her Orbit —	♌	2°	42	26
	North Node ſubſtract —	♒	7	47	36
	Argument Latitude —	5	24	54	50
	Reduction add —			1	11
	☾ in the Ecliptic —	♌	2	43	37
	Time of Reduction ſubſtract —			2	37
	Equal Time of the Ecliptic ☌ —		23	18	46
	Equation of Time ſubſtract —			5	57
	The apparent Time —		23	12	49
	Right Aſcenſion of the Sun —		125	0	
	Time from Noon in Degrees —	+	348	12	
	Right Aſcenſion of the *Med. Cæli* —		113	12	
	The Supplement —		66	48	
	M. Cæli in the Ecliptic —	♋	21	28	
	Meridian Angle —		80	58	
	Declination of the Culminating Point		21	46	N.
	Altitude of the Equator at *London* —		38	28	
	—— of the Mid-Heaven —		60	14	
	—— of the 90° —		60	38	
	Nonageſimal Degree in —	♋	16	20	
	Sun's Diſtance from it —		16	22	W
	Horizontal Parallax ☾ *a* ☉ —			53	48
	Parallax in Longitude ☾ *a* ☉ —			13	13
	Moon's true Latitude N. D. —			28	12
	Parallax in Latitude ☾ *a* ☉ —			26	23
	Viſible Latitude N. —			1	49
July 13.	To an Hour before the Ecliptic ☌ —		22	12	49
	Sun's Place then is —	♌	2	40	3
	His R. Aſcenſion —		124	58	
	Time from Noon in Degrees —		358	10	
	R. Aſcenſion of *Med. Cæli* —		98	10	
	M. C. in the Ecliptic —	♋	7	30	
	Angle at the Meridian —		86	45	
	Declination of the Culminating Point		23	16	
	Altitude of the Mid-Heaven —		61	44	
	—— of the Nonageſima Degree —		61	47	
	Nonageſimal Degree in —	♋	5	45	
	Diſtance of the Sun from it (Eaſt) —		26	55	
	Parallax in Longitude ☾ *a* ☉ —			21	28
	True hourly Motion ☾ *a* ☉ —			27	3
	Parallax in Long. decreaſing, (ſub.) —			8	15
	Viſible hourly Motion ☾ *a* ☉ —			18	48

Moon's

			′	″	
Moon's true Latitude, N. D.			30	52	
Parallax in Latitude ☾ *a* ☉ (ſub.)			25	26	
Viſible Latitude of the Moon N. D.		h.	5	26	
Apparent Time of the Ecliptic ♂		23	12	49	*July* 13.
Interval ſubſtract			42	11	1748.
Viſible Conjunction		22	30	38	
Sun's Place then	♌	2	40	45	
His Right Aſcenſion		124	58		
Degrees from Noon	+	337	40		
R. Aſ. *M. Cæli*		102	38		
The Supplement		77	22		
M. Cæli in the Ecliptic	♋	11	37		
Meridian Angle		85	0		
Declination of the Point Culminating		22	58		
Altitude of the M. H.		61	26		
—— of the 90°		61	33		
Its Place in the Ecliptic	♋	8	54		
Sun's Diſtance from it (Eaſt)		23	47		
Parallax in Longitude ☾ *a* ☉			19	5	
Moon's true Latitude N. D.			30	4	
Parallax in Latitude ☾ *a* ☉ ſub.			25	38	
Viſible Latitude ☾ N. D.			4	26	
Semi-diameter of the Sun			15	52	
—— of the Moon			14	47	
—— of the Penumbra			30	39	
Viſible Latitude of the Moon			4	26	
Parts deficient			26	13	
Digits Eclipſed		9	55		
Scruples of Incidence			30	25	
93′ and 55″ before the viſible ♂		20	59	11	*July* 13.
Sun then in	♌	2	37	1	
His R. Aſcenſion		124	54		
Time from Noon in Degrees		314	48		
R. Aſ. *M. Cæli*		79	42		
M. C. in the Ecliptic	♊	20	32		
Meridian Angle		85	55		
Declination of the Point N.		23	9		
Altitude of the Mid. Heaven		61	37		
—— of the 90th Degree		61	42		
Nonageſima Degree in	♊	22	44		
Sun's Longitude from it		39	55		
Parallax in Longitude ☾ *a* ☉			30	22	
True Motion of the ☾ *a* ☉ in 93′ : 55″			42	20	

Para-

	Parallax in Longitude decreasing			11	17
	Visible Mo. of ☾ *a* ☉ in the above Time			31	3
	True Latitude of the ☾ N. D.			34	14
	Parallax in Latitude sub.			25	31
	Visible Latitude ☾ N.D.			8	43
July 14.	97′ : 52″ after the visible ☌		0	10	58
	Place of the Sun then	♌	2	44	38
	His R. Ascension		125	2	
	Time in Degrees		2	44	30
	R. Ascension. *M. C.*		127	46	23
	M. C. in the Ecliptic	♌	5	24	
	Meridian Angle		75	52	
	Declinat. of the Culminating Point N.		18	57	
	Altitude of the M. H.		57	25	
	—— of the 90th Degree		58	31	
	Ninetieth Degree in	♋	26	32	
	Nonagesima Degree *a* ☉		6	12	
	Parallax in Longitude ☾ *a* ☉			4	57
	True Motion of the ☾ *a* ☉ in 97′ : 52″			44	7
	Parallax in Longitude, decreasing sub.			14	8
	Visible Mot. ☾ *a* ☉ in the above Time			29	59
	True Latitude of the ☾ N. D.			25	43
	Parallax in Latitude ☾ *a* ☉ sub.			28	6
	Visible Latitude of the ☾ S. Ascend.			2	23
	Mot. from the ☌ to the greatest Obscurat.				47
	Time ditto	+		32	28
	Time of Incidence		1	32	1
	Time of Repletion		1	39	18

Hence at LONDON, *July* 14, *Anno* 1748.

	h	′	″	
The Beginning will be at	IX	: 1	: 5	a. m.
The visible Conjunction at	X	: 30	: 38	
The Middle at	X	: 33	: 6	
The End at	XII	: 12	: 24	p. m.

The	total Duration	3 : 11	: 19
	Digits Eclipsed	9 : 55	

			′	″
Moon's visible Latitude at	Beginning	N. D.	8 :	43
	Middle	N. D.	4 :	26
	End	S. A.	2 :	23

The

The General ECLIPSE.

	h ′ ″	Latitude.	Longitude.
Begins at	8:22: 8	38:35	48: oW.
Is Central	9:37: o	49:12	69: 5 —
In the Meridian	10:56.12	53.18	16:10 E.
In the Nonageſima	11:11:20	50:24	22:15 —
Is at its neareſt Approach to the Center of the Diſk	11:18: 3	49: o	25:30 —
Ends Central	12:59:10	12: o	78: o —
Ends Entire	2:14: 5	o: o	56:15 —

in … and … From *London*.

	h ′ ″
The Central Duration	3:22:10
— total Duration	5:51:57
Angle of the Moon's Way	5:45: 9

This Eclipſe firſt takes the Earth on the Weſtern Part of the *Atlantic* Ocean, nearly in the middle betwixt the *Azores* and the Iſland *Bermudas*. The Annular Center makes its Entrance in North *America*, and, paſſing over *Newfound-Land*, enters *Europe* at the Iſle of *Mull* in *Scotland*: It paſſes nine Leagues North of *Edinburgh*, and leaves *Great Britain* at *St. Andrew's*; from thence, bending its courſe over the North Sea, it touches on *Germany* betwixt *Copenhagen* and *Hamburgh*, and paſſing on over part of *Poland*, *Turkey*, the *Levant*, and *Arabia* to the *Indian* Sea, at laſt on the South part of the *Mogul*'s Empire, the ſaid Center goes off from the Earth, and ſoon after the Eclipſe ends with the ſetting Sun.——The greateſt North Latitude of the Central Path will be 58°: 30′; the Longitude 17°: 30′ W. At *Stetten* in *Pomerania* the Sun will be Centrally Eclipſed exactly in the Meridian, and at *Cracow* in the Nonageſimal Degree. The Middle or Central Point of the general Tranſit falls about 20 Leagues E. of *Limburg* in *Little Ruſſia*; the tranſverſe Diameter of the Section 62 Leagues, the Conjugate 48.

		h ′
To *Madrid*, the Beginning	will be at	VIII: 48
the Middle	will be at	X : 12
the End	will be at	XI : 52

Digits Eclipſed —— — 6°: o′ North.

To

			h	′
To the Middle of *Iceland*, the	Beginning	will be at	VII	: 48
	Middle		IX	: 4
	End		X	: 26

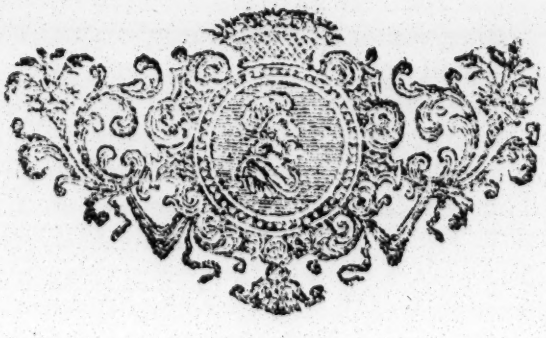
Digits Eclipſed —— —— 9° : 27′ South.

Mean Annular Duration of the Center two Minutes.

Digits —— —— 11° : 20′

For the ſeveral Types, ſee the Geometrical Conſtruction, Plate XI. And for the Way of the Shadow over *Scotland*, ſee Plate XII.

F I N I S.



POSTSCRIPT.

The Manner of Computing all Neighbouring Quantities, &c. of any *Solar Eclipſe* by APPROXIMATION.

		H.	M	S.	
Viſible Conjunction at *Edinburgh*		22	18	38	*July* 13, 1748.
Place of the Sun	♌	2	40	45	
His Right Aſcenſion		124	58		
Time from Noon in Degrees		334	39		
Right Aſcenſion of the *M. C.*		99	37		
Its Supplement to a Simicircle		80	23		
M. C. in the Ecliptic	♍	8	50		
Declination of the Point culminating		23	11		
Altitude of the Equinoctial		33	53		
—— of the *M. C.*		57	4		
Angle with the Meridian		86	11		
Altitude of the Nonageſima Degree		57	9		
Its Place in the Ecliptic	♎	6	22		
Sun's Diſtance from it		26	19		
Parallax of the ☾ *a* ☉ in Longitude			20′	2″	
—— in Latitude			29	11	
Time rectified (ſubſt.)			2	57	
Correct Time or viſible Conjunction		X.	15	42	*July* 14, in the Morning.
Moon's true Latitude N. D.			30	12	
Parallax in Latitude (ſubſt.)			29	10	
Viſible Latitude ☾ N.			1	2	
Digits Eclips'd		11°	12		
Duration of the Annular Appearance			2	6	

A TABLE of the Equality of Time and Degrees.

Hours of Time	Degrees of the Equator	Time	The Arch		Time	The Arch	
	Motion						
H	D	M	D	M	M	D	M
1	15	1		15	31	7	45
2	30	2		30	32	8	
3	45	3		45	33	8	15
4	60	4	1		34	8	30
5	75	5	1	15	35	8	45
6	90	6	1	30	36	9	
7	105	7	1	45	37	9	15
8	120	8	2		38	9	30
9	135	9	2	15	39	9	45
10	150	10	2	30	40	10	
11	165	11	2	45	41	10	15
12	180	12	3		42	10	30
13	195	13	3	15	43	10	45
14	210	14	3	30	44	11	
15	225	15	3	45	45	11	15
16	240	16	4		46	11	30
17	255	17	4	15	47	11	45
18	270	18	4	30	48	12	
19	285	19	4	45	49	12	15
20	300	20	5		50	12	30
21	315	21	5	15	51	12	45
22	330	22	5	30	52	13	
23	345	23	5	45	53	13	15
24	360	24	6		54	13	30
		25	6	15	55	13	45
		26	6	30	56	14	
		27	6	45	57	14	15
		28	7		58	14	30
		29	7	15	59	14	45
		30	7	30	60	15	

By this TABLE it appears that 18 Hours is equal to 270 Degrees, and that 4 Degrees and 45 Minutes is equal to 19 Minutes of Time, *&c.*

ERRATA.

E R R A T A.

In the TREATISE *on the* GLOBES.

PAGE 6, l. 22, for *Siderial*, r. *Sidereal.*
p. 23, l. 9, for *A I.* r. *A i.* p. 23, l. 15, for *intercepting*, r. *interſecting.*
p. 28, l. 13, for *minor*, r. *minus.*
p. 49, l. 23, for *Bermundas*, r. *Bermudas.*
p. 56, l. 16, for *Almicanther*, r. *Almacanter*, (and in many Places beſides.)
p. 70, l. ult. for *Compliment*, r. *Complement.*
p. 94, in Margin, del. *Plate XII.* p. 95, l. ult. del. *by Prob. X.*
p. 96, l. 3, for *draw a Line parallel to the Meridian*, r. *draw the Line of Azimuth.*
p. 96, l. 24, after *A*, &c. r. *Plate XII.*

In the Doctrine *of* ECLIPSES.

p. 109, l. 7, for *at O*, r. *at E.*
p. 110, l. 4, the * ſhould be after *full.*
p. 118, l. 4, from the bottom, for *Sun*, r. *Sum.*
p. 123, l. 4, (in the Notes) after 60, dele the firſt $35' : 35''$.
p. 134, l. 3, (in the Notes) for *inviſible*, r. *unknown.*
p. 137, l. 20, for *their*, r. *the.*
p. 140, l. 2, (in the Demonſtr.) for 23, r. 29.
p. 151, l. 5, from the bottom, for *Latitude*, r. *Longitude.*
p. 143, (in the Margin) for *Plate IX.* r. *X.*
p. 159, for *the Iſle of Mull*, r. *Iſle of Skie*; for 9 *Leagues*, r. 20 *Leagues*; and for *St. Andrew*, r. *Aberdeen.*

Now in the Graver's *Hands, and will ſpeedily be publiſhed by the* AUTHOR,

PHYSICAL and MATHEMATICAL ELEMENTS of ASTRONOMY, or the *DOCTRINE of the SPHERE:* Being a SYNOPSIS of the Univerſe, or the viſible World epitomiz'd, in an abſolute and entire Courſe of Cœleſtial Philoſophy, both ancient and modern, geometrically delineated: At one View, repreſenting and explaining the ſeveral known Laws and Principles of the *Planetary Syſtem.*

The Method is entirely new, and ſo intelligible, as to be eaſily comprehended by the youngeſt Proficient in that Study; highly beneficial for all Students, and extreamly uſeful to every Profeſſor and Tutor, for rendering the Inſtruction of their Pupils both ſpeedy and pleaſant: And (as it will be illuſtrated with ſeveral emblematic, and demonſtratory Schemes, together with various Hypotheſes, and Opinions of the moſt famous Authors) a very proper Ornament for the Libraries of the Curious. Price five Guineas.

As alſo, The ſecond Edition of the *Perpetual Pannauticon,* or the UNIVERSAL MARINER'S MAGAZINE. Shewing the Moon's Age and Phenomena for ever; the Ebbing and Flowing of the Sea to all Parts of the World, with the Poſition of the Tide at any time required; Latitude of the Place, and Hour of the Day or Night, by Obſervation; Southing of the fix'd Stars, and the Variation of Needle, *&c.* To which is added, a KEY, or EXPLANATION of it. In which all the Propoſitions and Rules are exemplified, *&c.*

Likewiſe an *Aſtronomical CYLINDER,* or SUN-DIAL; ſhewing the Sun's Place, his Altitude, Amplitude, and Azimuth, Time of the Day, Sun's Riſing and Setting, and Declination all at once, by only placing it perpendicular, and turning it to the Sun.

N. B. *The* Uſe of the Globes, *&c. are privately taught to Gentlemen and Ladies by the* AUTHOR.

Plate 1.

Fig. I.

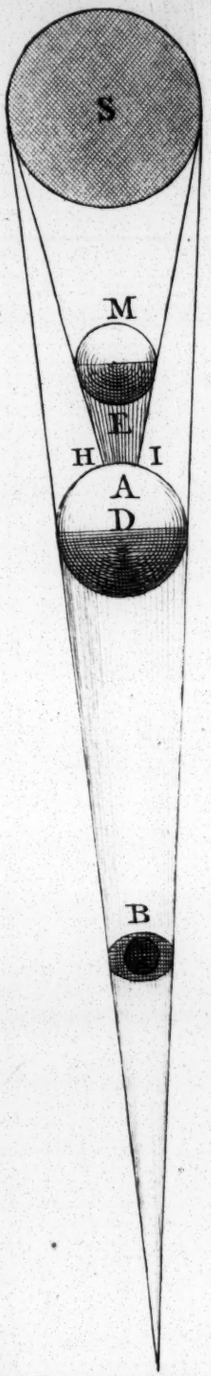


Fig. II.

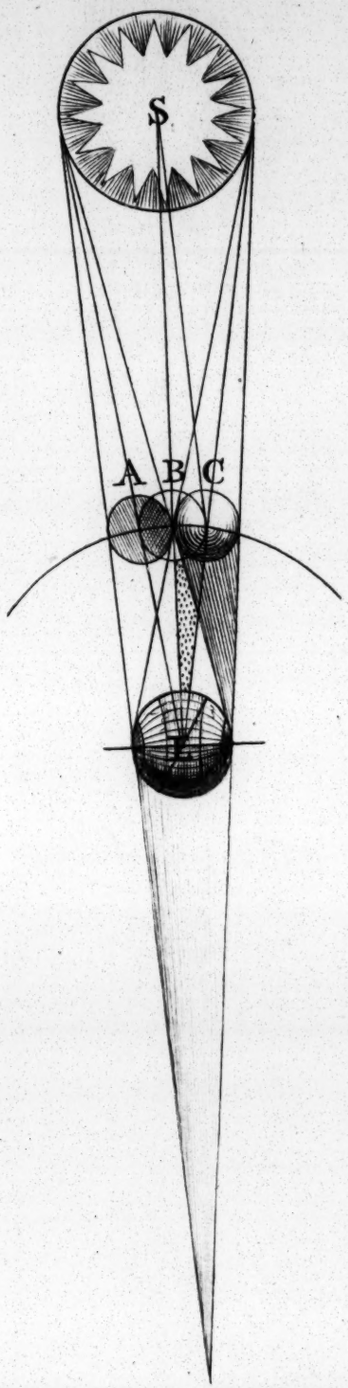


Fig. III.

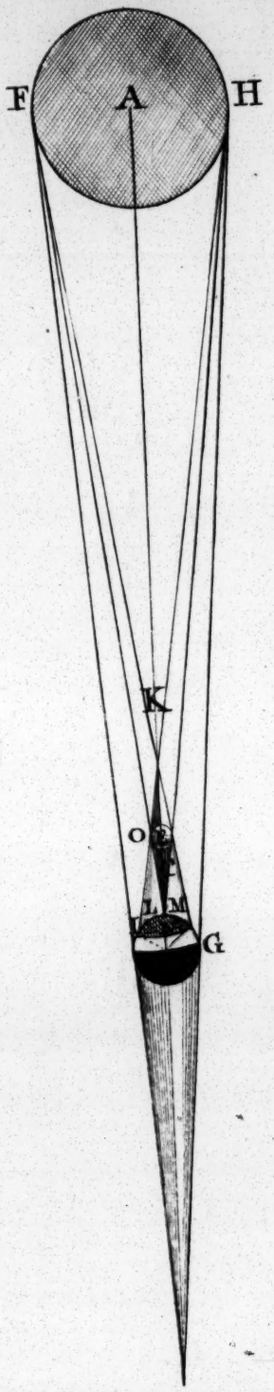


Plate 2.

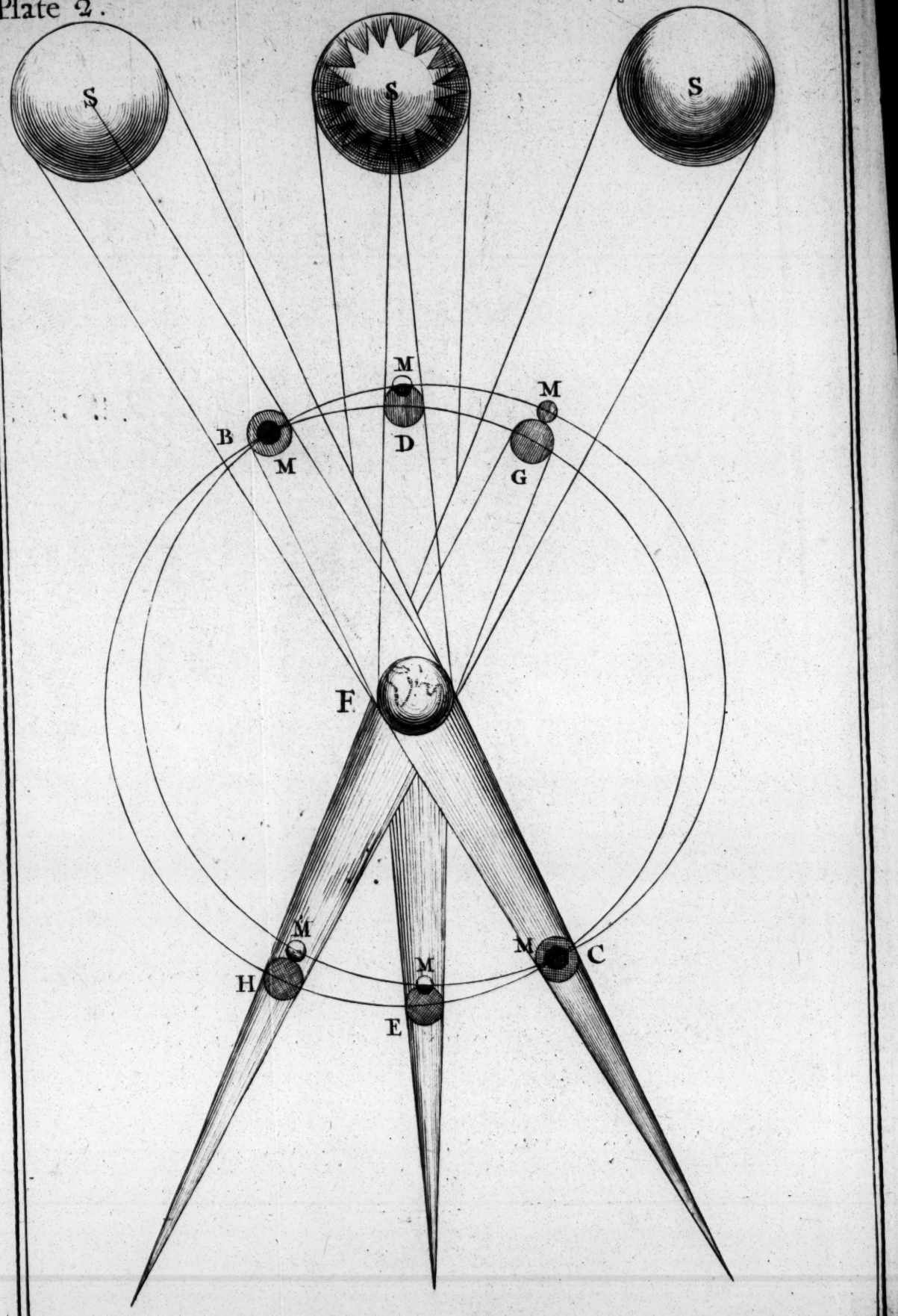


Plate 3.

Fig. 5.

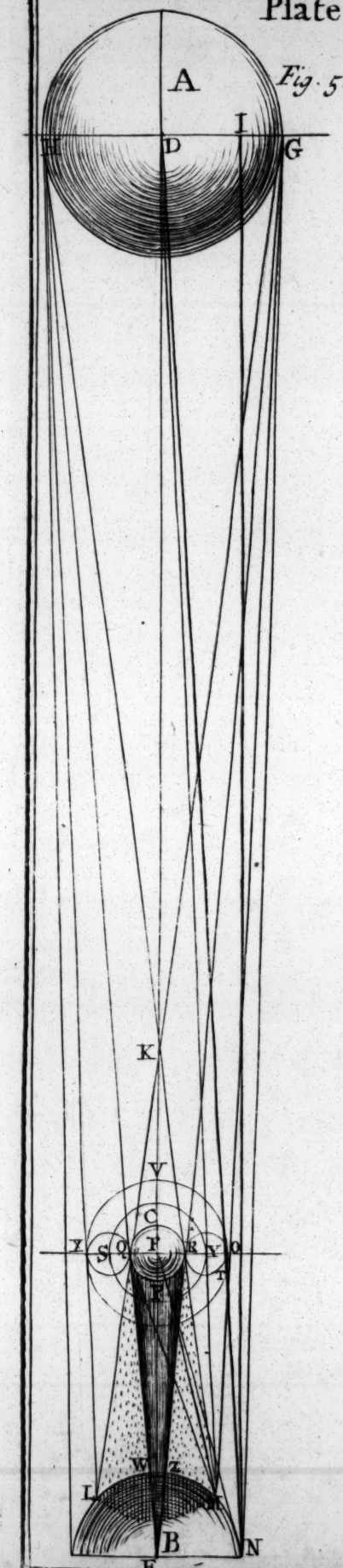


Fig. 6.

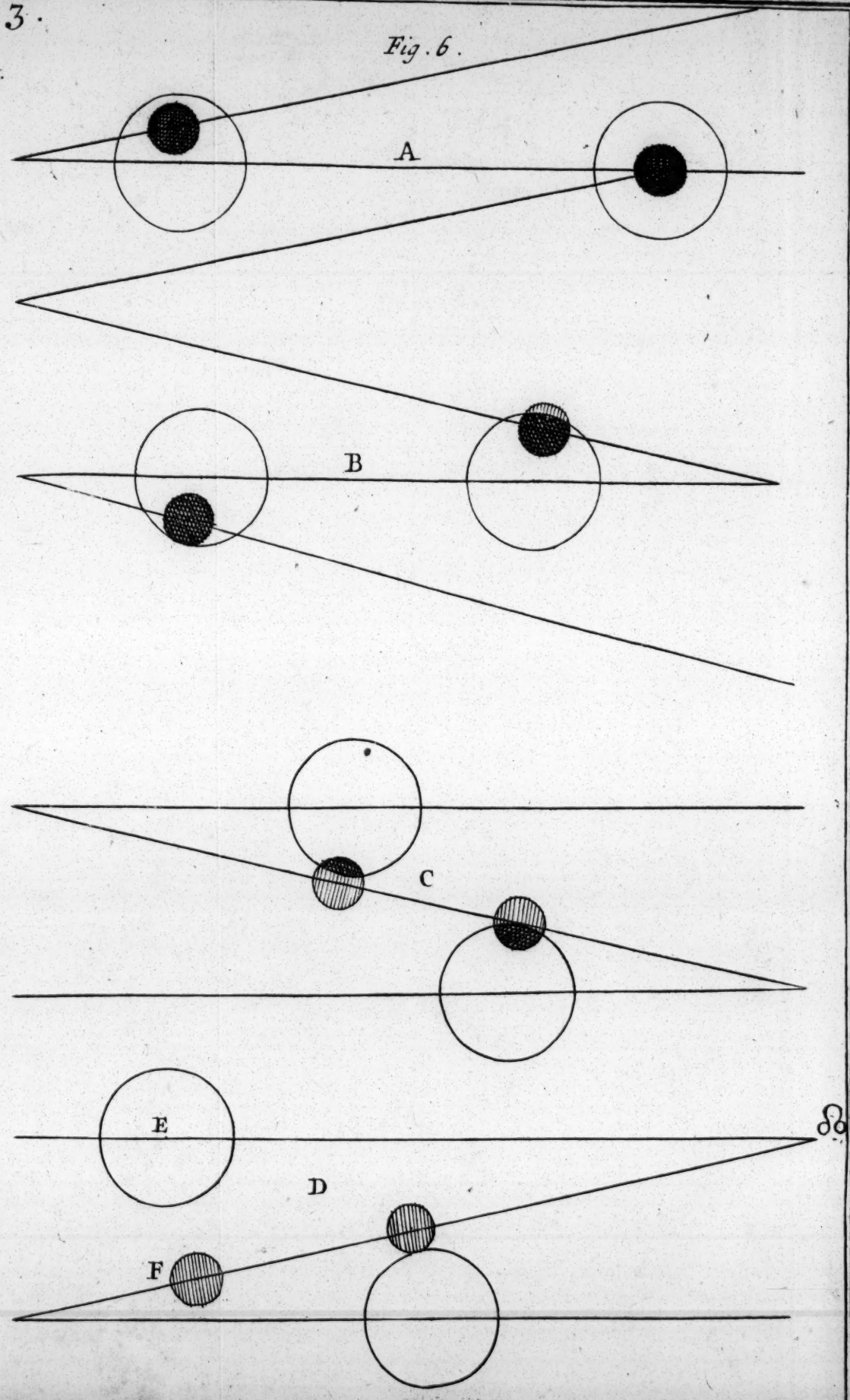


Plate 4.

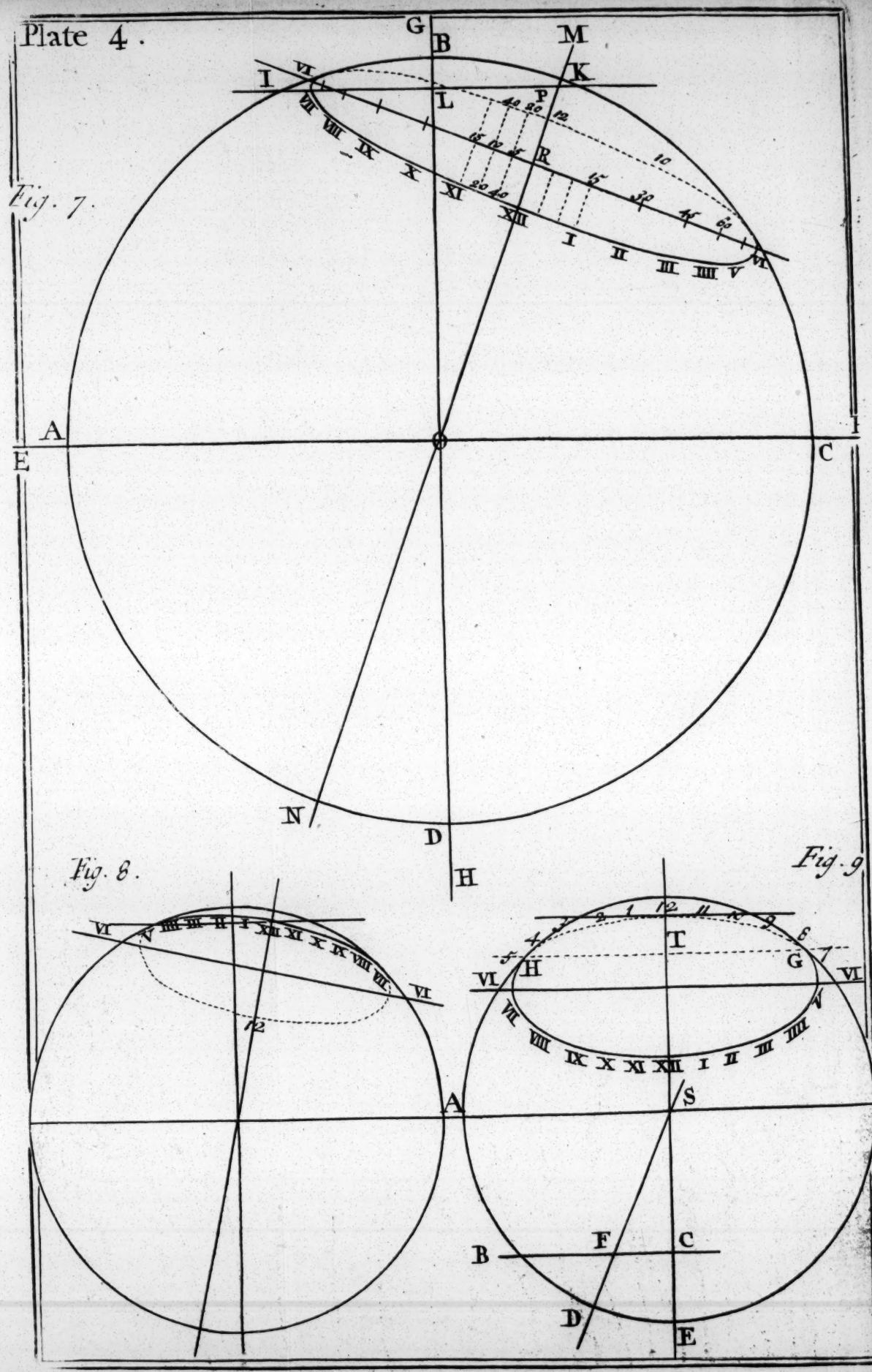


Fig. 7.

Fig. 8.

Fig. 9

Plate 5.

Fig. 10.

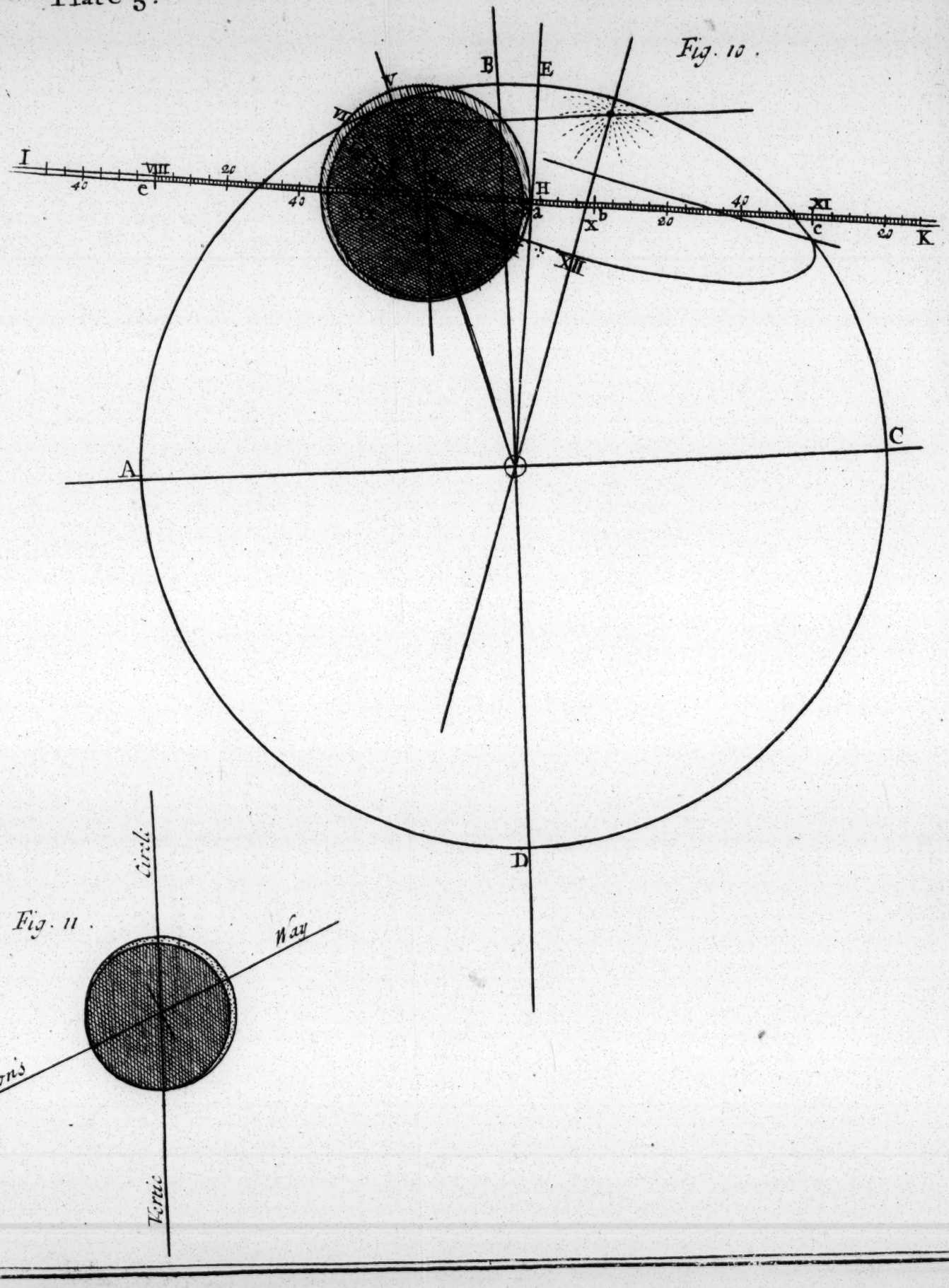
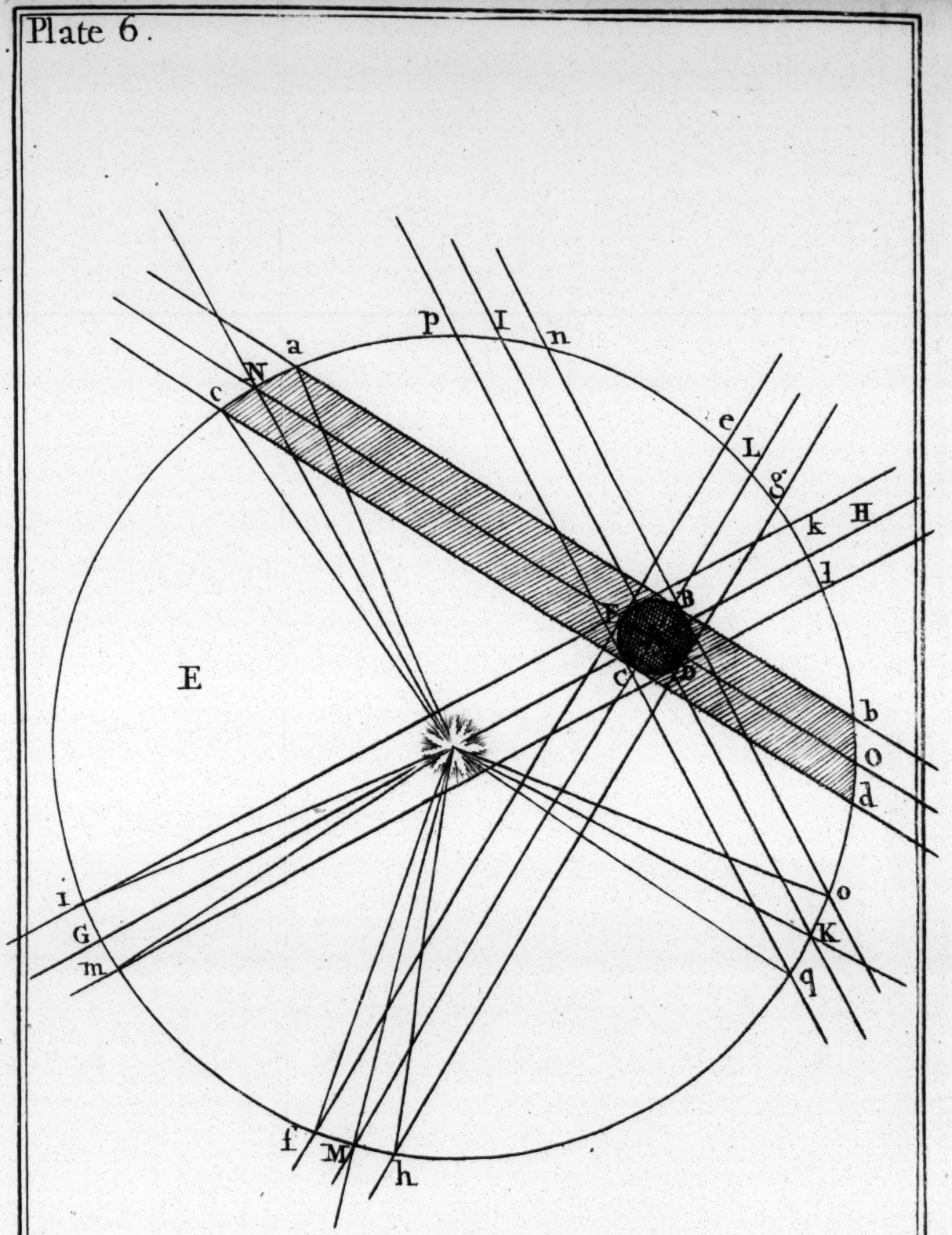


Fig. 11.

Plate 6.



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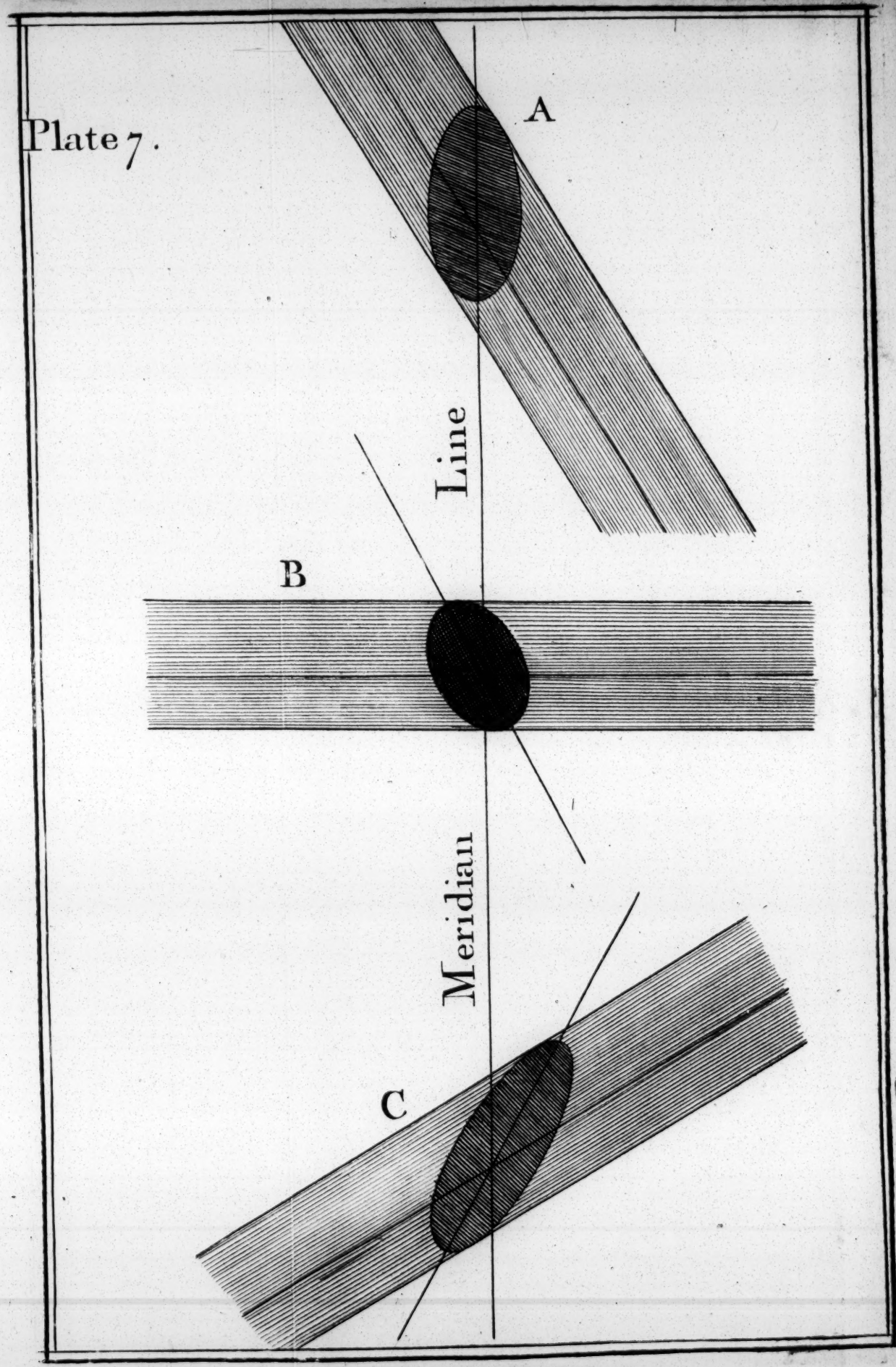


Plate 8.

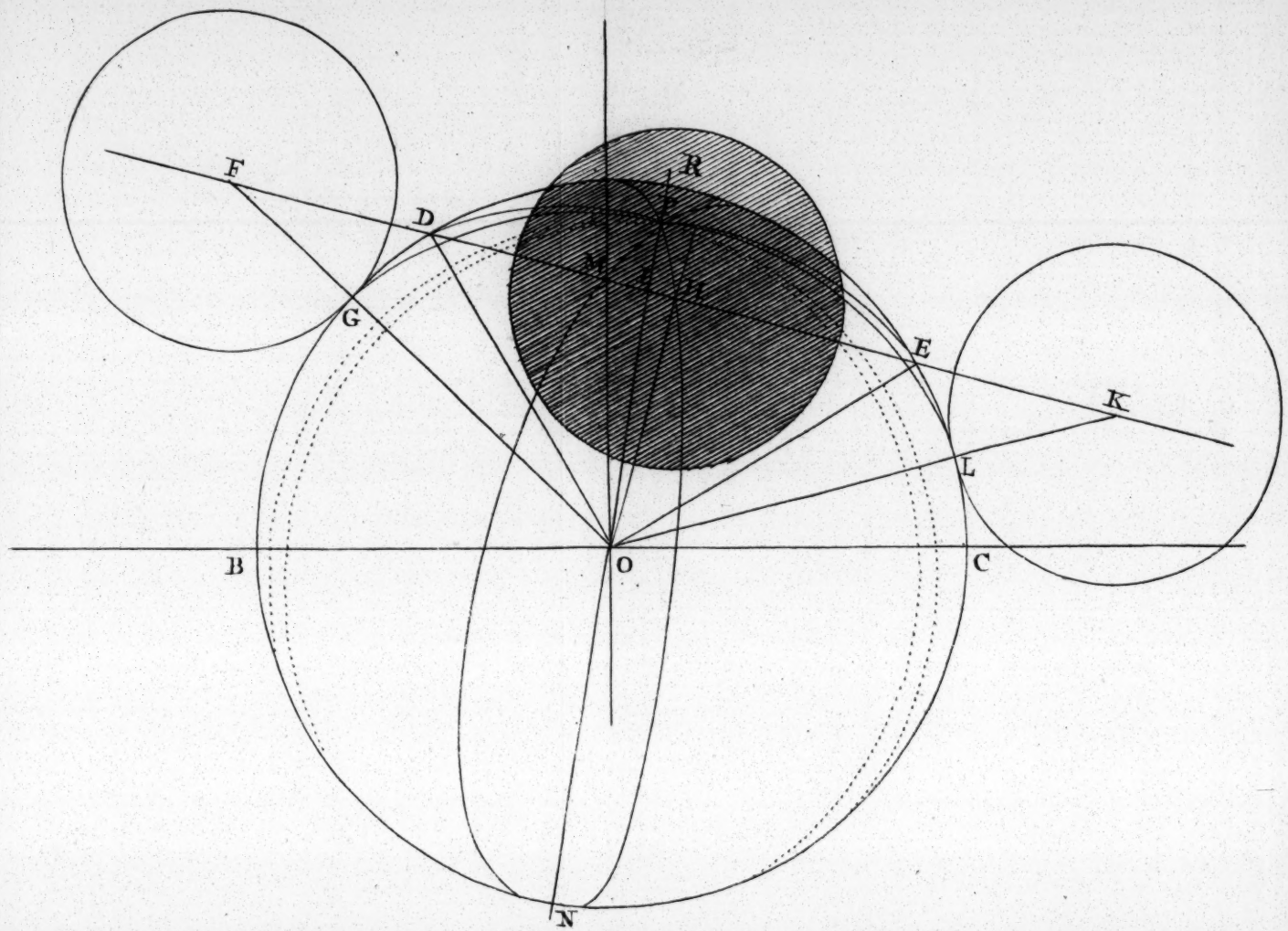


Plate 9.

Fig. 2.

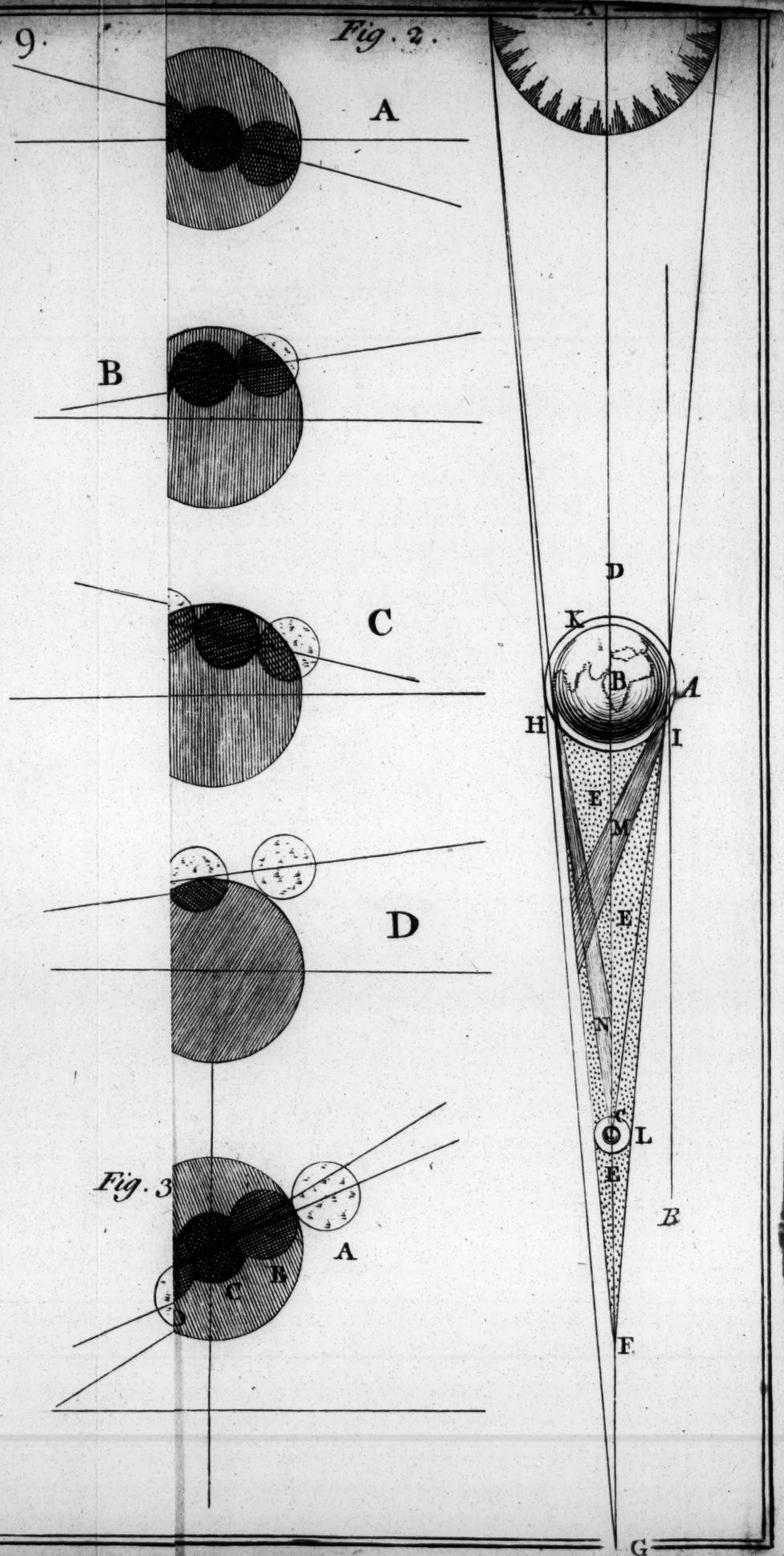


Fig. 3

Plate 10

Fig. 4.

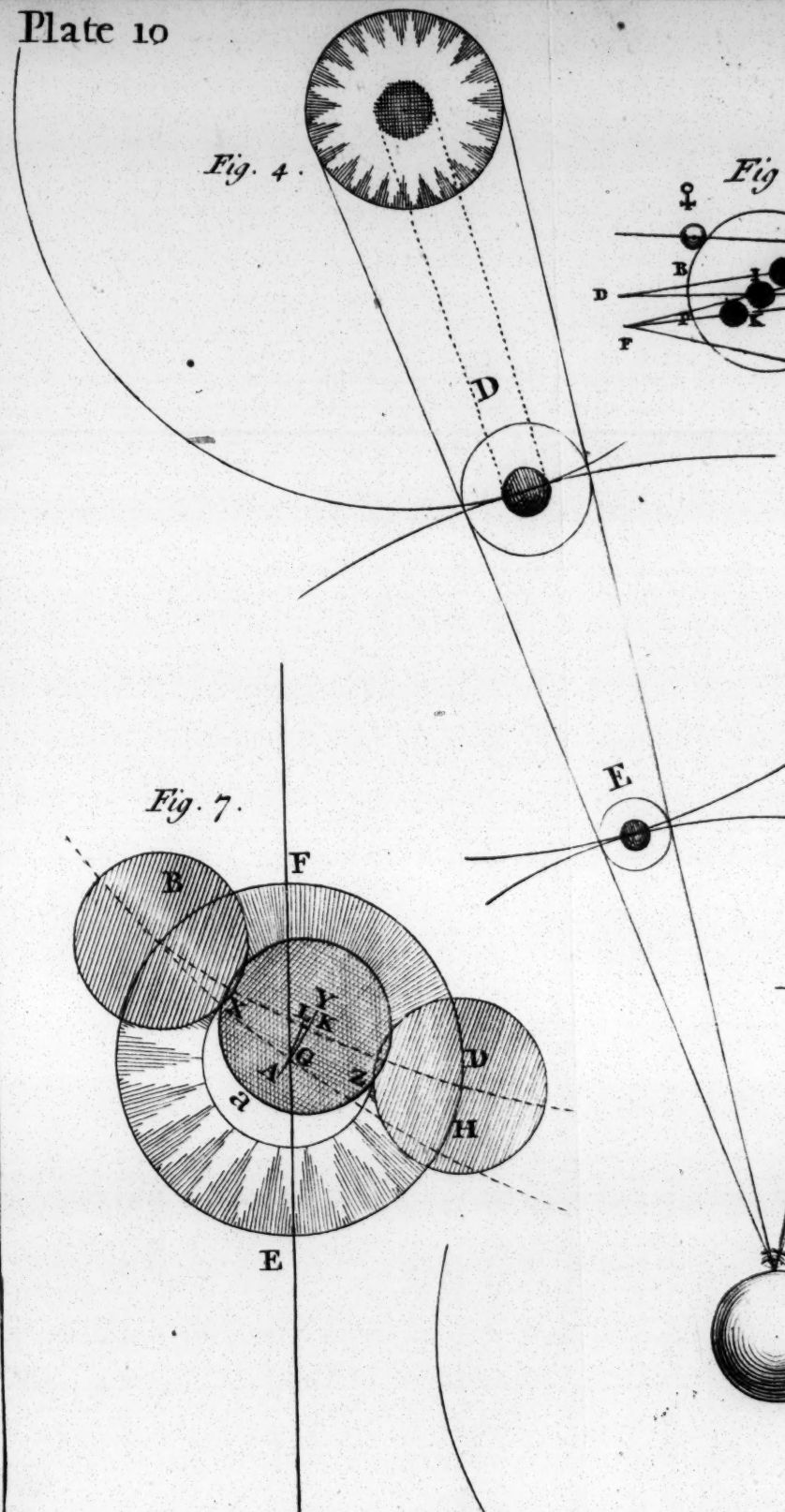


Fig. 5.

Fig. 6.

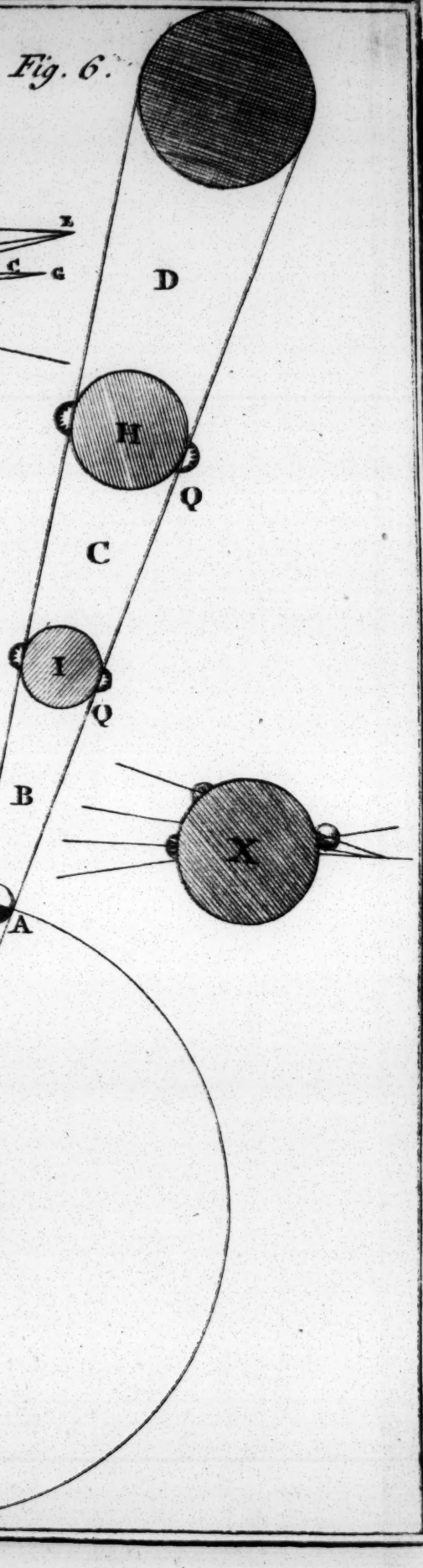


Fig. 7.

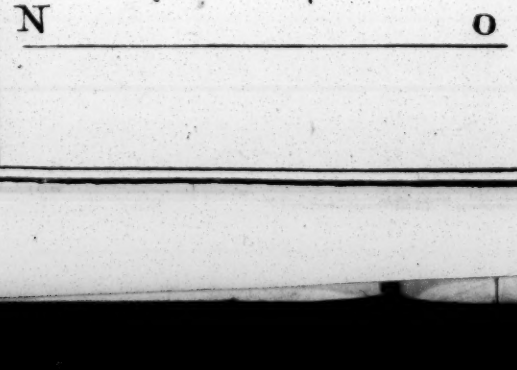
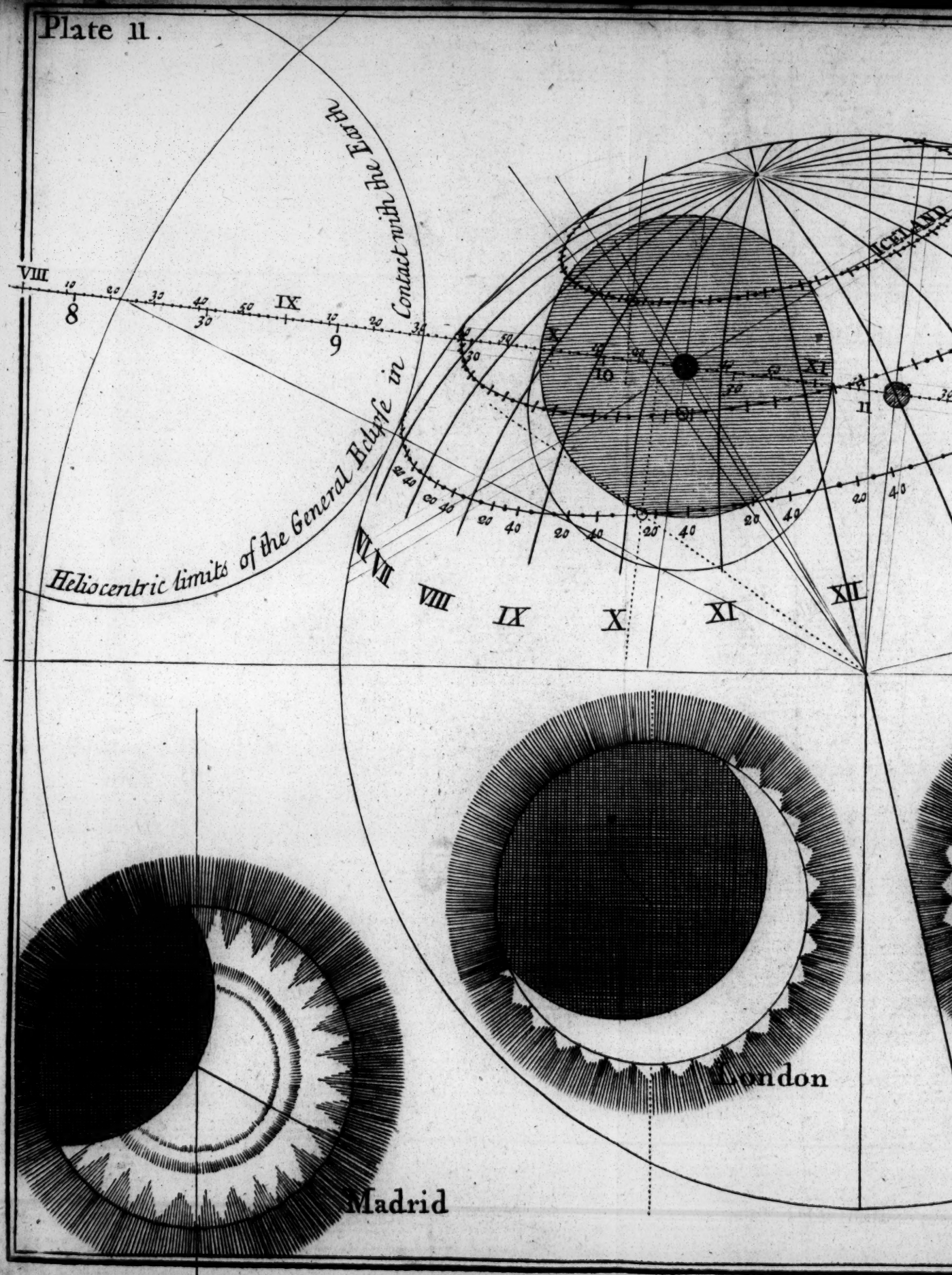
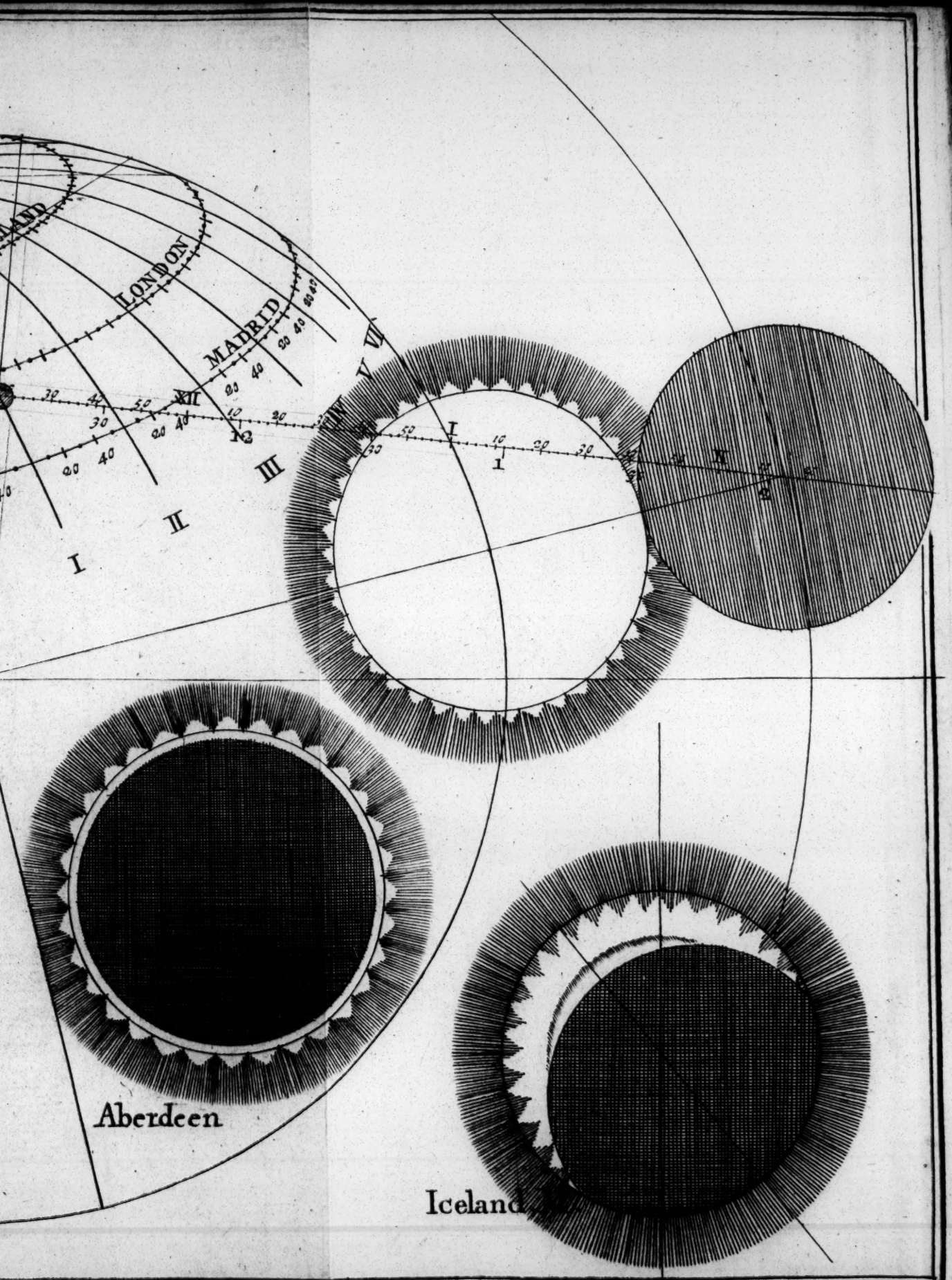


Plate 11.


Heliocentric limits of the General Eclipse in Contact with the Earth
VIII
IX
8
9
10
11
ICELAND
VI
VII
VIII
IX
X
XI
XII
London
Madrid


LONDON
MADRID
I
II
III
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V
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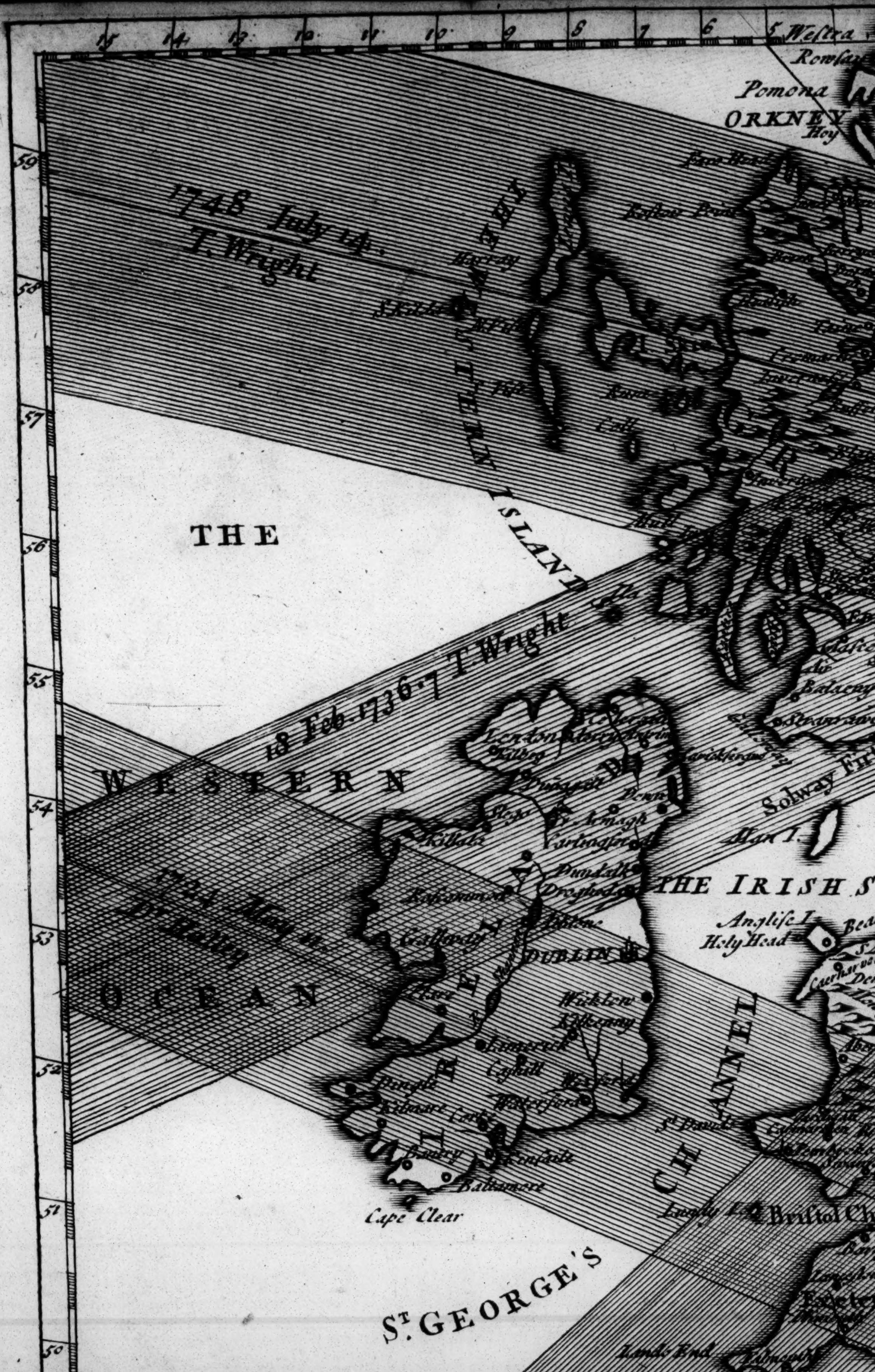
IX
X
XI
XII
Aberdeen
Iceland



ORKNEY
Pomona
Hoy
1748 July 14.
T. Wright
THE
WESTERN
OCEAN
18 Feb. 1736-7 T. Wright
1724 May 11
Dr Halley
THE IRISH S
Solway Fir
DUBLIN
Cape Clear
ST. GEORGE'S
CHANNEL
Bristol Ch
Holy Head
Lands End
Lizard

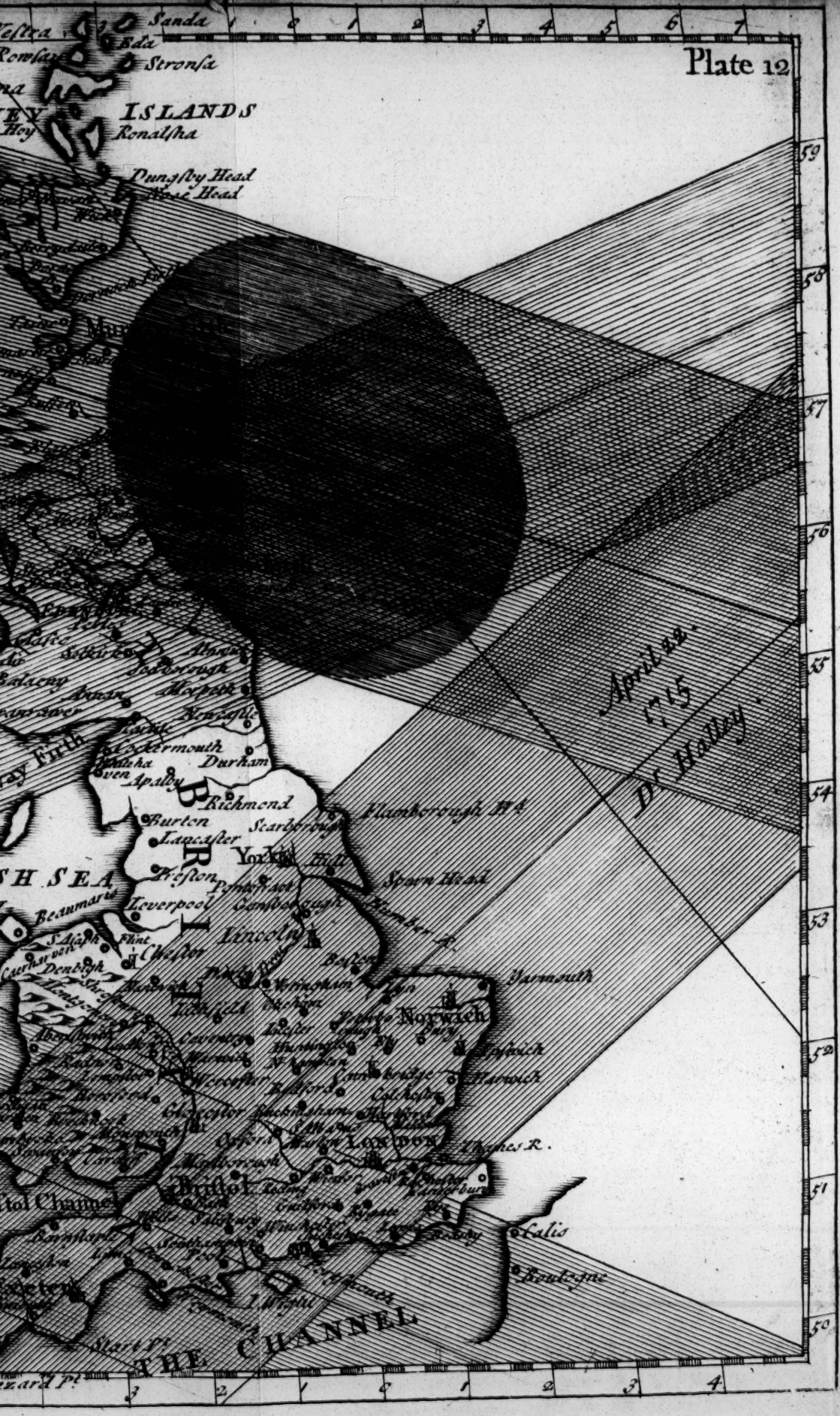


Plate 12
ISLANDS
Ronalsha
Dungsby Head
Noss Head
Stronsa
Sanda
Hoy
Durham
Richmond
Burton
Lancaster
York
Hull
Flamborough Hd
Spurn Head
Scarborough
Liverpool
Lincoln
Chester
Yarmouth
Norwich
Ipswich
Harwich
London
Thames R.
Bristol
Calis
Boulogne
THE CHANNEL
April 22.
1715
Dr Halley.
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